

ADDRESS

DELIVERED AT

THE ANNIVERSARY MEETING

OF THE

GEOLOGICAL SOCIETY OF LONDON,

On the 19th of FEBRUARY, 1858;

PREFACED BY

THE ANNOUNCEMENT OF THE AWARD

OF THE

WOLLASTON PALLADIUM MEDAL

AND PROCEEDS OF THE DONATION-FUND

FOR THE SAME YEAR.

By MAJOR-GENERAL PORTLOCK, R.E.,

LL.D., F.R.S., &c. &c.,

PRESIDENT OF THE SOCIETY.

LONDON:

PRINTED BY TAYLOR AND FRANCIS,

RED LION COURT, FLEET STREET.

1858.

PROCEEDINGS.

AT THE

ANNUAL GENERAL MEETING, *

19TH FEBRUARY, 1858.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

THE preceding Reports having been read, the President, MAJOR-GENERAL PORTLOCK, addressed the Meeting as follows:—

The Report of the Council has pointed out that its Members have on this occasion awarded two medals, thinking it desirable to mark, without delay, their high appreciation of the great merits of two most distinguished men, who, labouring in countries very distant from each other, have contributed largely to our knowledge of the ancient Natural History of the earth.

The first Medal has been assigned to a veteran Palæontologist, Hermann von Meyer, who commenced his labours twenty-three years ago by investigating the principle of determining the order and classification of mineral deposits by their natural-history relations. From that time he has been engaged in an uninterrupted course of Palæontological inquiries of the most varied nature, and he has become one of the leading authorities upon the subject in Germany. Sixteen years ago he was associated with Germar, Count Münster, and Professor Unger in that important work 'Beiträge zur Petrefaktenkunde,' or Contributions to the Knowledge of Fossils, which was rich in every branch of organic remains, whether animal or vegetable; and I find in the fifth part the description of a species of Pterodactyle, *Pterodactylus Meyeri*, discovered by Von Meyer himself, and named by Münster after his able coadjutor. Fossil Fishes and Fossil Plants were equally the subject of discussion in this able work, which extended to seven parts. He was associated with Plieninger in describing the Palæontology of Würtemberg, and he is now engaged with Dunker in publishing a general 'Palæontographica,' which has already recorded many interesting discoveries in this most rich and fascinating science. It will, I am sure, therefore, be felt that we are only doing justice to the claims of a man who has produced no less than 57 treatises upon Palæontological subjects, not one of which can be considered undeserving of respect and attention.

SIR C. LYELL,—It is with great pleasure that I place the Medal

in your hands, requesting that you will convey to M. Hermann von Meyer our high appreciation of the value of his labours, and our gratification at conveying it to him through one so fully able to value the services of a great Palæontologist.

SIR C. LYELL thus replied :—

Mr. President,—It will give me great pleasure to take charge of the Medal which has been awarded by the Geological Society of London to my friend M. Hermann von Meyer.

The importance of his Palæontological labours is now, as you have truly stated, universally acknowledged; but for my own part, I confess that I should scarcely have been aware of their vast extent had I not enjoyed opportunities of visiting Frankfort from year to year, and seeing the author engaged in his preparations for those monographs on fossil reptiles with which he has enriched our science. I see that one of the most splendid of these elaborate treatises, which contains I believe descriptions and illustrations of about 80 species of Triassic Reptiles, is now lying on our table—a work of which it is not too much to assert, that it would have secured a very high reputation for its author had it been the only labour of his life. For this and for his other publications, M. von Meyer has executed all the drawings with his own hand, and has done them all on transparent paper, so that his lithographer, when transferring them to stone, has not had to reverse the figures—a process during which the spirit and accuracy of the originals are often found to suffer.

Allow me, Sir, in conclusion, again to express to you the satisfaction I feel at being requested to transmit this well-earned tribute of our esteem to one of the most distinguished of our Foreign Members.

The PRESIDENT proceeded :—

The Council has awarded the second Medal to Mr. James Hall, of New York, as a testimonial of its high opinion of his merits as a palæontologist and geologist. Twenty-one years ago Mr. Hall exhibited his taste for palæontology by describing two species of Trilobites belonging to the genus *Paradoxides*, a genus very remarkable in its conformation, and which our friend Mr. William Rogers has lately discovered in a highly metamorphosed rock, long considered a crystalline schist, near Boston. His notes upon the geology of the Western States soon followed as a testimony to his love of pure geology; but the palæontology of New York proved him to be worthy of the respect of all lovers of natural science. He has gone steadily forward, and we are now indebted to him for an accurate knowledge of the geology and palæontology of the great State of New York, which is in itself equal to a large kingdom in magnitude. The last of his works, “Descriptions of New Species of Palæozoic Fossils from the Lower Helderberg, Oriskany Sandstone, Upper Helderberg, Hamilton, and Chemung groups,” published last year, is full of descriptions of new species; and, although I am myself prone to hesitate respecting new species when closely allied to previously known species, the

work proves the continued energy and ability of Mr. Hall in his favourite study.

To me it has always appeared, that the history of any of the past epochs of the earth's history may best be studied in countries which have not undergone any great disturbance during its continuance. In England, from its insular position, it is easy to observe that numerous disturbances must have interfered with the tranquil course of events, whilst in large continents, such as America, and a large portion of the continent of Europe, such as Russia, &c., little comparative disturbance may be looked for, and the succession of organic existences may be supposed to have gone on under the influence of ordinary and natural causes alone. Such considerations as these are the more interesting at the present moment as Sir R. Murchison has lately been enabled to establish the Silurian age of certain rocks in Scotland, by the discovery in them of Silurian fossils, not of the English type, but of the American type, amongst which may be mentioned the genus *Maclurea*, so called after one of the first writers on American Geology, the well-known Mr. Maclure. This curious fact adds to our interest in the award of this Medal, which we wish to be considered as a testimony of the high respect which our Society entertains for the labours of American geologists, and especially for those of Mr. James Hall. I should have felt much pleasure in transmitting the Medal through Professor Ramsay, who during the last summer represented our Society at the Meeting of American Naturalists in Canada; but in his absence, I naturally turn to you, Sir Roderick Murchison, as the natural leader on every question relating to the Silurian Formation, and who would have been our representative in America had you not found it necessary, from ill-health, to decline the pleasing duty in favour of Professor Ramsay, who may be considered almost your pupil. Let me then request you to undertake the task of conveying the Medal to Mr. James Hall, and expressing our high respect for him and his labours. The Council has added the proceeds in the hope that the sum, though small, may be of use to Mr. Hall in the publication of his fossils.

In reply SIR R. MURCHISON said :—

Sir,—Although I am unexpectedly called upon, through the accidental absence of Professor Ramsay, to receive the Wollaston Medal for Mr. James Hall, I beg to assure you, that no one of my countrymen can more truly rejoice than I do in the adjudication of the highest honour this Society can bestow, to so eminent an American geologist.

In my earnest desire to have visited the United States and Canada last summer—a desire which was alone frustrated by the state of my health,—my chief gratification would have been to have examined, under the guidance of James Hall, those great expanses of the Silurian and other palæozoic rocks of the Western Continent which he has so truthfully and ably described; for it is he who has shown us that, however widely separated by the Atlantic, the fossil remains of the earliest traceable living things in the New World have, like the present inhabitants, the strongest relationship with the old country. Permit

me, Sir, also to say, that the high estimate of the merits of our medallist, which I have imbibed, both from a study of his own works and by reference to the opinions of Lyell, De Verneuil, and Logan, has been much strengthened by the animated reports of Professor Ramsay, who since his return has lost no opportunity of recording the deep sense he entertains of the very important services rendered to Geological science by the arduous and meritorious researches of James Hall.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT.

Proceeding now to the more special duty which devolves on your President this day, I have once more to perform the melancholy task of recalling to our memory the names of those Fellows of our Society who have been removed from amongst us, by death, during the year; and it is with sorrow that I find how erroneous was the hope I entertained last year, that the very magnitude of the losses I then commemorated would insure me from having to dwell in the present year, for any length of time, upon so sad a subject. It was indeed scarcely to be expected that we should have been, as a large Society, entirely exempted from the common lot of humanity; but the blow has fallen most heavily upon us, and amongst our losses we have to record the names of men distinguished in almost every branch of literary or scientific lore.

The first I shall notice was indeed a patriarch of our science, one of those illustrious men who assisted at the very birth of Geology amongst us, one who was long looked up to as a sure guide in the path of truth and science. You will at once perceive that I allude to the late DEAN CONYBEARE, who last came amongst us only a very short time before the summer recess, when he appeared to take as lively an interest as ever in the proceedings of the Society he had once cheered by his frequent attendance, and adorned by his labours; and as he was going away he assured me that it was always with pleasure and satisfaction he came to meetings from which duty and distant residence could alone keep him away.

It has been justly said that he was one of a race of clergymen, and those men of intellectual eminence. His grandfather was Dean of Christchurch and Bishop of Bristol, the friend of Bishop Berkely, and the author of a work distinguished even in an age of deep thinkers and profound theologians, and entitled 'The Defence of Revealed Religion.' The Bishop's only son, Dr. William Conybeare, Rector of Bishopsgate, left behind him two sons, both of whom were eminent men. The elder, John Josias, Vicar of Bath Easton, was an accomplished scholar, no inconsiderable chemist, a sound geologist, and filled with credit the University offices of Professor of Poetry and of Anglo-Saxon, as well as that of Bampton Lecturer: he promoted the revival of Saxon literature, and left behind him, on his death in early life, a volume of translations which it was his brother's office to complete and edit. That brother, the second son of Dr. William Conybeare, was the illustrious object of this notice,

William Daniel Conybeare: he was born in June 1787, and in due time sent to Westminster School, where he received his early education. From Westminster he proceeded to Oxford, and entered Christ Church in the same year as his fellow collegian Sir Robert Peel, taking a first class in classics, in which he was classed with Sir Robert, and a second class in mathematics, in which he was classed with Archbishop Whately. Until he took his M.A. degree, he continued to reside at the University, pursuing various studies, and assisting by his exertions to lay the foundation of Geology, which was then only a rising science. At the early portion of the present century, an indifference, such as we can now scarcely understand, as to the cultivation of the natural sciences prevailed at Oxford; but, in the midst of the consequent general neglect, a small band of individuals, residents of the University, were united in the effort to keep alive a taste for at least one branch of natural science, and succeeded in enlisting others in its cause.

The first lectures given at Oxford on Mineralogy, which was then as a study not accurately distinguished from Geology, were, it is believed, those delivered by Sir Christopher Pegge, then Regius Professor of Medicine; and although it may not be possible, either from written records or from the personal testimony of any one now living, to form an accurate opinion of the merits of those lectures, it may be fairly assumed that they were not destitute of attractiveness, as the same individual delivered long afterwards lectures on Anatomy, remarkable for an elegance and a fluency of diction which have caused them to continue fresh in the recollection of many. Sir Christopher Pegge was succeeded by Dr. Kidd, who for several years gave courses of lectures at Oxford on both the allied sciences, Mineralogy and Geology, and collected around him a knot of persons interested in similar pursuits, who formed themselves into a little club of Oxford Geologists. This club included amongst its members the late Dr. Buckland, the two brothers Conybeare, the late Rev. Philip Serle, of Trinity College, afterwards Rector of Addington, Oxford, and many others, who, though less vigorously devoting themselves to geological research, were still, from their eminent qualities and high character, most instrumental in keeping alive the growing interest for the new science, and in raising the character of the club so high, that some of the early members of the Geological Society of London, then in its infancy, amongst whom were the late Mr. Greenough and the present patriarch of our science, Dr. Fitton, were in the habit of paying an annual visit in Whitsun-week to the University, in order to explore, under the guidance of the geologists of Oxford, the physical structure of the rocks in its neighbourhood; whilst, on their part, they thus judiciously enlisted local inquirers in the service of general geology.

The venerable Principal of Magdalen College, Dr. Macbride, is the only survivor, at Oxford, of this memorable club, and he preserves at an advanced age the vigour of his faculties, and exhibits all his former interest in the progress of learning and of science; but of non-residents, there still survive Archdeacon Hony, now Prebendary of Sarum,

and Mr. Philip Duncan, who now resides at Bath: the latter and his brother, Mr. John Grant, were Fellows of New College, were honoured by the degree of D.C.L., and were remarkable, not only for their love of natural history, but for their zealous support of every philanthropic and scientific object. The Rev. William D. Conybeare was, however, in the first rank of this little body, and stood so high in the estimation of all its members, that Dr. Buckland, when first lecturing as the successor to Dr. Kidd, expressed in the warmest terms his sense of the obligations he owed to him for the information he had imparted on points relating to geology, and his persuasion that it would not have been fitting for him to offer himself to fill the office of lecturer on that subject, had Mr. Conybeare been desirous to occupy it. Let me add here, that another equally eminent individual, the founder of the new school of geology at Cambridge, as Dr. Buckland was of that of Oxford, has assured me, with a similar frankness, so characteristic of Professor Sedgwick, that he too looked upon Dean Conybeare as his early master in geology.

In 1814 Mr. Conybeare married, and retired from the University, the scene of his early triumphs, to undertake the quiet work of a country curacy, and nine years afterwards removed to the vicarage of Sully in Glamorganshire, on the presentation of the late Evan Thomas, Esq., his brother-in-law; but, whilst holding the curacy of Banbury and Lectureship of Brislington, near Bristol, he had been mainly instrumental in conjunction with Sir Henry Delabecche, in founding the Bristol Philosophical Institution and Museum, and it was at that time he received a visit from the great French geologists, M. Elie de Beaumont and M. Dufrénoy, who came for the purpose of acquiring a knowledge of the secondary rocks of England, as a standard of reference for those of France; and he so impressed them, whilst acting as their companion and guide in an exploration of the neighbourhood, with a deep sense of his geological knowledge, that they were prepared on their return to cooperate with Cuvier in obtaining the election of Mr. Conybeare as a corresponding member of the Institute, for Geology. Nor must it be supposed that this excellent man neglected his sacred duties whilst storing his mind with the richest treasures of geological research, as it was during his residence at Sully that he delivered, gratuitously, at the request of his friend Dr. Prichard, a course of theological lectures at Bristol College, of which institution he had become a visitor.

In 1836 he left Sully and went to Devonshire, having presented himself to his family living of Axminster, and, whilst there, preached, at the request of the authorities of the University of Oxford, the Bampton Lecture for 1839. The living of Axminster he resigned after a few years, on being called by his friend Bishop Copleston to the care of the Cathedral of Llandaff. Here he continued zealously to carry on the good work of restoration which had been commenced by his predecessor Dean Bruce Knight; and, as at all times in his life, was ever ready to distribute the rich and varied stores of his mind for the benefit of his fellow-men, in whatsoever station of life they might have been. This venerable, much-loved man, and

admired philosopher, left Llandaff to attend the death-bed of his eldest son, and, whilst pausing in his return, at the house of another son, was stricken with pulmonary apoplexy, and died on the morning of the 12th of August, after an illness of only three hours, in the 71st year of his age.

Such is the general picture of the life of a truly estimable man; and I shall now add to it a very brief notice of his most characteristic works, premising, however, that, even before the peace of 1815 had opened the Continent to British geologists, Mr. Conybeare had formed, from the imperfect data then within his reach, a sound opinion as to the identity of the Jura limestone with the oolitic formations of England, an anticipation which he had afterwards the gratification, in conjunction with Dr. Buckland and Mr. Greenough, of verifying. The versatility of the genius of Dean Conybeare led him to examine and describe the lesser points connected with organic remains, as well as the greater; a circumstance in which he strongly resembled his friend and fellow-labourer Dr. Buckland. For an exemplification of this peculiarity of his mind, I shall refer to his paper published in the year 1814, in the second volume of the Transactions of the Society, and therefore one of his early contributions to Palaeontological Science. It was entitled, "On the Origin of a remarkable Class of Organic Impressions occurring in Nodules of Flint." Mr. Parkinson had described them as "small round compressed bodies, not exceeding the eighth of an inch in their longest diameters, and horizontally disposed, connected by processes nearly of the fineness of a hair, which pass from different parts of each of these bodies, and are attached to the surrounding ones; the whole of these bodies being thus held in connexion." Mr. Parkinson considered that these bodies were the works of polypes; and he therefore classed them with corals of some unknown genera; and Dr. Buckland, who had directed his attention to them simultaneously with Mr. Conybeare, considered that the moulds in which the siliceous casts had been formed were the work of parasitic insects, the thin hair-like appendages having been the passages of entry first made by the insects, and the larger flattened bodies the cavities afterwards excavated, the object of the excavation having of course been to obtain nourishment from the body thus eaten into, whether a shell or any other. This observation of Dr. Buckland was communicated to Mr. Conybeare, but not until he had completed his own researches, and arrived at the same virtual conclusion,—namely, that "these cellules were the works of animalcules preying on shells and on the vermes inhabiting them." In arriving at this conclusion, Mr. Conybeare was guided by the examination of various fragments of shells, still preserved in contact with the siliceous matter which had subsequently been infiltrated into the cavities produced by the boring animal. These appear to have been portions of shells distinguished by a striated texture, and were stated by Mr. Conybeare to resemble in structure the recent *Pinna marina*, as the genus *Luceramus* does; but in addition to these, Mr. Conybeare found them connected with other shells, and even with an *Echinus* and a *Belemnite*. Though

Mr. Conybeare spoke with diffidence of his having brought before the Society a paper on such minute palæontology, it cannot be doubted that the interest connected with the discovery of the existence and workings of minute marine animals at so remote an epoch is of a very high order. The flints and other siliceous deposits of the chalk and other geological epochs, have indeed been striking examples of the effect of judicious investigation in rendering the most obscure objects the means of throwing light upon natural phenomena.

Mr. Conybeare was fully aware of the necessity of studying physical as well as organic phenomena in connexion with geological science; and it is truly surprising how often the intimate connexion of the physical geography of remote epochs with their natural history is overlooked. His description of the land-slip which occurred on the coast of Culverhole Point, near Axmouth, in December 1839, was ably illustrated by a series of lithographic plates from the drawings of the present Lieut.-Colonel Dawson; and the magnitude of the results was well expressed by the following words:—"Although this convulsion can only be ascribed to the less dignified agency of the land-springs constantly undermining the sub-strata, yet, in the grandeur of the disturbances it has occasioned, it far exceeds the ravages of the earthquakes of Calabria, and almost rivals the vast volcanic fissures of the Val del Boye on the flanks of *Ætna*." Without doubt these phenomena are very striking and interesting in themselves; but they become still more so when we reflect, as Mr. Robert Mallet has taught us to do, that they ought not to be confined to the existing epoch alone, but should be sought for in the stony records of past ages. The paper on the Hydrographical Basin of the Thames, written with a view to determine the causes which had operated in forming the Valleys of the Thames and its tributary streams, is equally valuable as tending to maintain the value of attending to physical geography in geological investigations. His examination, also, of the Theory of Mountain-chains, then recently propounded by M. Elie de Beaumont, as well as his remarks on the phenomena of geology which most directly bear on theoretical speculations, are proofs of the truly philosophical and enlarged view he took of his favourite science.

In noticing the works of Dr. Buckland, I have already detailed the importance of the paper which was compiled by him in conjunction with Mr. Conybeare, on the Bristol and South Welsh Coal-fields; one, as I then observed, of those elaborate and comprehensive papers which were the fitting work of the first pioneers of geological science, and the difficulty of which can scarcely be appreciated in these times when the foundations of the science have been fairly laid, and geologists have only to improve or correct the details. His remarks on the sections of the Antrim and Derry coast were also a conjoint work, and of much interest.

Another and equally remarkable work was that undertaken in conjunction with the late Mr. William Phillips, namely, the 'Outlines of the Geology of England and Wales,' as it may be considered the first systematic work on the subject; and, though geology has been since

more specialized and studied in minuter detail, this work will always be regarded as a striking proof of the ability and knowledge of the authors.

It was, however, in 1821 (April 6) that Mr. Conybeare communicated to the Society that remarkable Palæontological paper which excited so much interest at the time, and established in the most satisfactory manner the propriety of establishing a new genus of *Reptilia*, forming an intermediate link between the *Ichthyosaurus* and Crocodile, to which Mr. Conybeare gave the name of *Plesiosaurus*.

The discovery of immense vertebræ of oviparous quadrupeds in the Lias near Bristol had attracted the attention of Mr. Conybeare, who quickly recognized the difference between those belonging to the *Ichthyosaurus* and others, which evidently, in his opinion, were portions of a different animal. With a singular judgment and rare sagacity, he placed the detached vertebræ in their proper position, and finally established his new genus, for which he adopted the name *Plesiosaurus*, as expressing its near approach to the order Lacerta.

For the whole group of animals which approximate, on the one hand, to the Crocodiles in general organization, and yet have been provided with such specific organs as were necessary to enable them to live, at least principally, in the sea, Mr. Conybeare proposed the name *Enalio-sauri*, as a classic appellation for the whole order; and he observes of the genera composing it, that even the *Ichthyosaurus*, which recedes most widely from the forms of the Lizard family, and approaches nearest to those of fishes, exhibits in its osteology a beautiful series of analogies with that of the Crocodile, and which widely remove it from fishes.

In this paper he then described in the minutest detail the osteology of the *Ichthyosaurus*, and exhibited a knowledge of anatomy which excited the admiration of every one. He then examined with equal care the relics of the new genus, which, although at that time not complete, were sufficient to enable Mr. Conybeare to conclude that the vertebral column recedes from that of the *Ichthyosaurus* in all the points in which the latter approaches to the fishy structure, and that the invertebral substance must have been disposed much as in *Cetacea*; and that, from the locking together of the articulating processes, it must have had much less flexibility than in the *Ichthyosaurus* or in fishes. In examining also such portions of the paddles as could be arranged in order, he comes to a similar conclusion in another direction, namely, that the paddles of the *Plesiosaurus* are intermediate in character between those of the *Ichthyosaurus* and the Sea-turtles; and thus in every respect he laid a sound foundation for his new genus.

It is to be remarked that this paper was given as the joint production of Mr. Conybeare and Sir Henry Delabèche, to whom Mr. Conybeare most liberally ascribed a full share of the merit of the discovery; but, allowing Sir Henry every praise for his assistance in that discovery and in all the geological details, I believe the sagacity and skill exhibited in the osteological details and reasonings have always been ascribed to Mr. Conybeare.

In a second paper, read May 3, 1822, Mr. Conybeare was enabled to describe much more fully all the relations of the genera *Ichthyosaurus* and *Plesiosaurus*, from the discovery of other remains, both of the *Ichthyosaurus* and *Plesiosaurus*, by his coadjutor Sir Henry Delabecche. A very minute examination of the teeth, especially, enabled him to point out that those of the *Ichthyosaurus* were more intimately related to the teeth of the Crocodile than to those of other *Lacerte* (an opinion then at variance with the opinions of some anatomists), whilst at the same time, in other respects, the analogy was in the other direction, for Conybeare observes, "in pursuing, however, the history of the teeth of the *Ichthyosaurus* to the last stage, we quit these analogies with the Crocodile, and arrive at another point wherein the *Ichthyosaurus* resembles the other *Lacerte*, in common with many of the *Mammalia*: this is, the gradual obliteration of the interior cavity in old age, by the ossification of the pulpy nucleus." In conjunction with Sir H. Delabecche he brought up the number of species to four, determined from the teeth; and in his further consideration of the genus it is right to notice the following remarks, proceeding from him after noticing a difference in one character of the fossil Crocodile, when compared with the recent, as stated by Cuvier:—"I am persuaded, from every circumstance, that a much nearer approximation to the structure of the older lacertian genera will be found in the fossil than in the recent Crocodiles; interesting links in the chain of Saurian animals will be thus supplied, and it will probably be found that many of the points in which the *Ichthyosaurus* differs from the recent type are only instances of its agreement with the fossil."

The researches of Sir H. Delabecche had not at this time led to the discovery of a complete skeleton of the new genus *Plesiosaurus*; but additional portions of it were found, including a very perfect dental bone of the lower jaw, whilst a tolerably perfect head was discovered by Mr. Thomas Clarke in the Lias of Street, near Glastonbury.

The investigation of these new relics of the *Plesiosaurus* led Mr. Conybeare to the following conclusion: "On the whole then, the manner in which the ribs of the *Plesiosaurus* articulate throughout, by a single head, to the extremity of the transverse processes of the vertebrae only, the structure of the humero-sternal parts, and the characters derived from the head, approximate this animal most nearly to the *Lacerte*. By its teeth, on the other hand, it is allied to the Crocodile; while its small nostrils and multarticulate paddles are features in which it resembles the *Ichthyosaurus*." This able paper he concluded with words characteristic of his natural modesty, after pointing out the difficulty of rendering anatomical details at once scientifically accurate and yet attractive to a general audience: "I need not add how much these difficulties will be increased in the hands of a writer who must acknowledge that, while intruding on the province of the comparative anatomist, he stands on foreign ground, and, using almost a foreign language, is frequently driven to adopt an awkward periphrasis, where a single word from the pen of a master would probably have been sufficient."

However some may at the time have been inclined to throw doubts upon the deductions of Conybeare, the ability and accurate discrimination of the author were publicly recognized by the great Cuvier, who hastened to advocate his admission to the French Academy as a Corresponding Member for the Science of Geology; and I am sure that all living palæontologists will follow the example of the late well-known, and at that time so highly respected, Mr. Clift, in recognizing the great merits of Dean Conybeare, and considering him one of the principal founders of the science in this country.

At the present moment it would be tedious and unnecessary to pass in review the whole of the long series of Mr. Conybeare's geological works, nineteen in number; and I shall point your attention therefore solely to that able "Report on the Progress, Actual State, and Ulterior Prospects of Geological Science," which he presented to the British Association in 1832, at its meeting in Oxford, in which he treats the subject with the combined powers of the scholar and man of science, pointing out the remarkable analogy in the views of Leibnitz to those of many modern speculators on physical geology; the opinions of Hooke in respect to the hypothesis of the elevation of our continents by volcanic agency; the masterly observations of Smith, first made known in 1799, which, although not the first to originate the doctrine of a regular distribution of organic remains, yet reduced to certainty and order what had been before vague and conjectural; the gradual rise of the Tertiary Geology from its foundation in the admirable 'Mémorial on the Basin of Paris,' by Cuvier and Brongniart, published in 1811; the establishment of the Geological Society in 1808, and the labours of all the great men connected with it, including, amongst many others, Greenough, Buckland, Sedgwick, Rytton, Murchison, De la Beche, Phillips, Serpé, Daubeny, and Lyell, together with those of foreign geologists, including the great Von Buch and Boué. That Report alone is sufficient to prove his masterly acquaintance with the history of his favourite science, and with all its bearings, whilst it marks the liberal spirit with which he entered into all geological inquiries. The advance of geology since that Report has been enormous; and, if a period of twenty years from the publication of Cuvier and Brongniart had done so much in raising Tertiary Geology to a high position, may we not say that the result of the next twenty-five years has been still more remarkable, and has richly rewarded the continued and judicious researches of some of our most distinguished geologists, such as Lyell, Forbes, Prestwich, and Austen, whilst the elevation to which the Silurian system has arrived by the persevering exertions of Murchison is a monument of progress which we can scarcely hope will be equalled in that peculiar branch of geology in future times.

The zeal of Dean Conybeare for geology never forsook him; and when obliged to visit Madeira on account of the health of his youngest son, he visited the Peak of Teneriffe, and studied the other volcanic phenomena of the neighbouring islands. How deeply must we regret that his last days were embittered by sorrow for the death of another son, from whose funeral he was returning at the time of his

death! But so excellent a man, prepared for death by the strict performance of every christian duty during life, requires not the commiseration of those who survive him; although all who recollect his air of gravity and of sincerity, which always made his words effective in commanding attention and respect, and in bringing home conviction to the minds of his hearers, must feel how heavy a loss we have experienced.

The next person whom I shall notice, though unquestionably not possessed of the same extensive range of intellectual acquirements as the illustrious individual of whom I have just spoken, was yet a most active, intelligent, and valuable member of our Society. MR. JOSHUA TRIMMER was the eldest son of Joshua Kirby Trimmer (who was the eldest son of Mrs. Trimmer the well-known authoress), and was born at North Cray in Kent, on the 11th of July, 1795. When he was about four years old his parents removed to Brentford, Middlesex, in order to be near the authoress, who resided in that parish. Under the roof of that venerable and widowed relative, much of the early childhood of the subject of this memoir was passed. The attention of the authoress was first particularly drawn to this grandchild by accidentally hearing him explain to a younger member of his family, rules of christian conduct to be observed through life—rules which, being entirely approved of by Mrs. Trimmer, were scrupulously followed out by himself in his own life. His docile disposition and inquiring mind gained her especial notice and affection, and he was held up by her to her various juvenile descendants as one whom they would do well to endeavour to resemble. It was indeed recorded of him, in the published life of Mrs. Trimmer, “that Sunday was to him a day of perfect felicity; and whether he sat with his book under a tree, or examined with his venerable grandmother the beauties of the plants and flowers, his countenance shone with delight; and in the winter, when such pleasures could not be recurred to, the day was still one of enjoyment, and never wearied him.”

His taste for the science of geology was innate: his aged mother, who survives to mourn his loss, well remembers that at a very early age, when he used to accompany her and the authoress in their walks, his chief delight was to ramble to the side of a river or of a canal in search of shells, which he would bring to the authoress that she might name them; and frequently when at home he would invite his mother's attention to the organic formations on oyster-shells, expressing the strongest desire to learn their natural history. Though the favourite study of his life appears to have originated with himself, his daily converse with the venerable Mrs. Trimmer, who was emphatically “the child's friend,” confirmed his early tastes, and assisted in training his mind for that keen observation and searching inquiry which so characterized his subsequent geological pursuits; and it is worthy of remark, that these two relatives in their separate writings, directed as they were to widely different subjects, arrived at the same inductive conclusion with reference to eternal truth. The authoress, in a little publication entitled

"The Knowledge of Nature, for the instruction of Children," has this remark: "It is evident from the construction of every part of nature, from the noblest to the most insignificant, that they are all most admirably formed; they must therefore have been the work of some wise, powerful Being, infinitely our superior;" whilst the closing words of her grandson, in his work on "Practical Geology and Mineralogy," are, "The structure of the earth, as well as the mechanism of the heavens, proclaims the Divinity of the Hand which made them. The one tells of power and wisdom displayed through the immensity of space, the other tells of the same attributes displayed through the immensity of time; and thus every bone and shell and leaf disinterred from the dust of the earth leads our thoughts towards eternity and the world of spirits, and tells us that, though all things visible are subject to change, they are the work of one invisible and eternal Being, 'the same yesterday, today, and for ever.'"

About the year 1806, young Trimmer was placed as a pupil with the Rev. William Davison, at that time Curate of New Brentford. Under that highly talented preceptor, he pursued his classical and mathematical studies with such diligence as to gain the esteem of his preceptor, which he retained until his decease in the year 1852.

When about nineteen years of age, he superintended for his father some copper-mines in North Wales; whilst thus employed, he gained a practical knowledge of mineralogy. After several years he undertook for his father the management of a farm in Middlesex; and, being thus engaged for some years, he acquired during that period a portion of that knowledge of soils which in after-life he so prominently connected with geology. During this period of his life he continued to reside with his parents, and his evenings were not unfrequently spent in Scriptural study. When engaged in other reading, the poet Spenser was his especial favourite; and his intimate acquaintance with every page of the "*Faerie Queene*" may have furnished him in part with that great command of language, so frequently evident in his writings. In prose-writing his model was Addison, the elegance of whose periods he admired: not unlike that author, he wrote with the greatest facility, never pausing for ideas or for language to express them; and it was not his habit to reconstruct any sentence he had once written: he composed also with ease in poetry, and gave expression to his thoughts in flowing and harmonious verse, and at an early age translated from the Italian a considerable portion of Tasso's "*Jerusalem delivered*."

In the year 1825 he was again in North Wales, working for his father some slate-quarries, one of them situate at Bangor, and the other two between Snowdon and Caernarvon. At the latter town he established, by means of public subscriptions, a museum, to which he gave many valuable organic remains, some of which he had met with when occasionally visiting Ireland, but the greater part he had long been engaged in collecting from the ossiferous deposits at Brentford. Whilst working these quarries, at which employment he continued for some years, he resided chiefly in the Vale of Nantlle, where he was occasionally visited by his friend the late Dr. Buckland, whom

he would at such times guide with enthusiastic ardour over the Snowdonian range, pointing out to him from time to time the erratic blocks and marine shells on which he founded his opinion that they were not deposited, as had been supposed, by melting icebergs on the floor of a sea, which after long submergence had been converted into dry land by movements of elevation, but that they were spread by marine currents of extraordinary energy and short duration over the surface of pre-existing land, and over land covered with ice. This opinion, however, he subsequently modified by accepting coast-ice as being probably an efficient agent in these circumstances.

About the year 1840 he ceased to reside in Wales, and was for some time afterwards employed in the Government Geological Survey of England. He then returned to reside in his native county, Kent, in which he continued until the time of his decease. The last few years of his life were entirely devoted to writing on agricultural subjects in connexion with geology, more especially on the drainage of lands, in which he insisted on the following points:—

1. The important influence exercised by the superficial deposits on the distribution of soils.

2. The division of those deposits into erratic tertiaries, or Northern drift, and warp-drift.

3. The division of the erratic tertiaries again into lower and upper erratics,—the lower erratics consisting of boulder-clay, possessing peculiar characters found in no other marine strata; the upper erratics composed of rolled gravel and sand, approaching more the characters of ordinary tertiary strata, but distinguished from them by certain marked peculiarities.

4. The distinctness of the warp-drift, a deposit which generally forms the surface-soil, and its subsequent origin to that of the erratic tertiaries; its presence in those districts where the erratic tertiaries are absent, and its diffusion over their denuded surface where they are present.

5. The indented surface of the beds, whether of the erratic tertiaries or of the older strata, on which the warp-drift rests, presenting a series of irregular ridges and furrows.

6. The suggestion that the contradictory statements which abound respecting the superior efficacy of deep or shallow drains, of drains at wide or narrow intervals, of drains following the fall of the ground, or crossing it, might perhaps, in many cases, be reconciled by observing whether the drains were parallel or transverse to these natural furrows and ridges.

Among the numerous publications of Mr. Trimmer may be mentioned the following, which strongly mark the bent of his mind, and the practical objects he more especially had in view:—

1. On the Diluvial or Northern Drift of the Eastern and Western sides of the Cambrian Chain, and on its connexion with a similar Deposit on the Eastern side of Ireland, at Bray, Howth, and Glenismaile.
2. On the Origin of the Soils which cover the Chalk of Kent. In two parts.
3. Practical Geology and Mineralogy, with an Introductory Discourse on the Nature, Tendency, and Advantages of Geo-

logical Pursuits. 8vo, with two hundred illustrations. 4. Practical Chemistry for Farmers and Landowners. 5. Proposals for a Geological Survey, specially directed to Agricultural Objects. 6. On the Geology of Norfolk, as Illustrating the Laws of the Distribution of Soils. 7. An Attempt to estimate the Effects of Protecting Duties on the Profits of Agriculture. 8. Supplement to the same. 9. On the Agricultural Geology of England and Wales. Prize Essay. 10. Notes on the Geology of the New Forest, in relation to its capabilities for the growth of Oak, and for cultivation. 11. On the Agricultural Relations of the Western Portion of the Hampshire Tertiary District, and on the Agricultural Importance of the Marls of the New Forest. 12. On the Southern Termination of the Erratic Tertiaries, and on the Remains of a Bed of Gravel on the Summit of Clevedon Down, Somersetshire. 13. On the Erratic Tertiaries bordering on the Penine Chain. In two parts. 14. The Keythorpe System of Land Drainage; its Principles, Efficiency, Economy, and Opponents. 15. On the Geology of the Keythorpe Estate.

He was in the midst of preparing another work for the press, to have been entitled 'Soils, Subsoils, and Substrata; or, The Geology of Agriculture,' when, whilst walking in London, he was seized with an illness which after a few days terminated fatally, on the 16th of September, 1857.

The catalogue of Mr. Trimmer's works is sufficient to show that he was a most zealous, active, and practically useful geologist. When first I had the pleasure of becoming acquainted with him, he was distinguished as an enthusiastic advocate of the diluvian theory of the drift, considering that great waves had been lifted up and carried over the pre-existing dry land, scooping out channels and depositing marine debris; but this advocacy of a peculiar theory in no way interfered with his examinations, which were always made with care, and detailed with honesty. In June 1831 and January 1832, he communicated two short notices to our Society, on diluvial phenomena, as he then considered them, noticing the discovery of marine shells in diluvial sand on the summit of Moel Tryfane, near Caernarvon, 1000 feet above the level of the sea, and again, on a visit to Runcorn, the discovery of marine shells in a singular deposit, forming part of the banks of the Mersey. It consists of a series of beds:—

1st. Yellowsand, with some pebbles, but no shells, 3 to 6 feet thick;

2nd. Decayed vegetable matter, $\frac{1}{2}$ to 3 inches thick;

3rd. A bed 14 feet thick, to high-water mark, containing fragments of new red sandstone and erratic pebbles of various crystalline and other rocks, associated with a few blocks, of great weight, up to a quarter of a ton; and in this bed he found portions of shells belonging to *Cardium*, *Turritella*, and *Buccinum*, and he ascribed this phenomenon to an irruption of the sea.

In 1838, at the meeting of the British Association at Newcastle, he pointed out the occurrence of marine shells covering the vestiges of terrestrial phenomena in Cefn Cave in Denbighshire, and again alluded to his former discovery, having also communicated the results of both discoveries to the Geological Society of Dublin,—a body

to which he was much attached, and by whom he was much respected. Perhaps no one ever laboured with more zeal and with more ability to discover all the phenomena connected with drift-deposits, or to reduce them to a diluvial origin; but, as time went on, he appears to have fallen into the more general views entertained on the subject, and, though he probably greatly modified his original opinions, many of his discoveries were of great use to other geologists, and have been noticed with respect by them, as, for example, by Mr. Conybeare, in his Report on Geology. In 1841, he published his work entitled 'Practical Geology and Mineralogy,' a work of very considerable merit, and especially remarkable for the sound and liberal views which he sets forth on that long-disputed subject, the description of creation in Genesis. "The assaults of revelation," he observes, "usually assume, and too many of its defenders argue on the assumption, that we have reason to expect a system of physical science in the sacred writings; but the slightest consideration of the purpose for which they were given must convince us that such a revelation would have been quite at variance with their professed object. That object was to make man acquainted with his relations to his Creator, with his original state, his present condition, his future hopes." Would that those who still keep up the argument, whether friends or enemies of science, would adhere to this view of the object of Scripture, and neither embitter the minds of their opponents by acrimonious disputations, nor endanger the cause of true religion by injudicious assertions!

Our late friend, for I must emphatically call him so, was frequently engaged of late in discussing the origin of the sand-pipes of the chalk; and his papers are so recent that all must recollect how steadily he maintained their production by the wearing action of the sea, in opposition to that by the eroding action of water charged with carbonic acid. In this, as in most other geological phenomena, every form of sand-pipe cannot perhaps be explained by any one cause; and it would therefore be unwise to reject *in toto* any reasonable cause, correct in principle, because incapable of explaining every effect. The wisest plan is to adopt a give-and-take principle, and to ascribe each separate effect to its own natural and efficient cause.

The very useful manner in which Mr. Trimmer had latterly applied his extensive knowledge of drift-formations to practical draining, obtained for him the patronage of Lord Berners of Keythorpe as a large and scientific agriculturist, and must cause him to be deeply regretted by that important and valuable class of society, the practical farmers: it had, indeed, been his principal object through life to make science an instrument in promoting the welfare of mankind; and his own predilection for the theory of currents, whether passing over the surface of dry land, or at the bottom of a sea, producing a furrowed surface, led him to resort to such furrows as a natural system of drains. We shall long remember him as an enthusiastic yet unprejudiced geologist, and as a simple-minded, frank and honourable man, the worthy descendant of the friend of some of our childish days, Mrs. Trimmer.

As a man of very high intellectual acquirements, and as one who filled the office of Secretary of our Society in 1837, Dr. ROYLE deserves to be long remembered with respect and affection by us all. It has always been the pride of our Society to know that its officers were distinguished for their high position amongst men of science; and it is not necessary now to enforce the great truth that mental superiority in any one branch of natural science cannot fail to exercise a beneficial influence on the cultivators of every other great collateral branch. But though Dr. Royle has fully merited our warmest encomiums for his botanical researches alone, he deserves them also for the aid he has given towards the advancement of a knowledge of the geology of India, although he does not appear to have professed himself exclusively a geologist. As a proof of this I may cite a memoir on the geological features of the Himalaya Mountains, which forms part of his great work, "Illustrations," to be hereafter mentioned. This memoir was accompanied by some extensive sections,—namely, one across the Himalaya Mountains; one from Salarunpore to the Source of the Jumna; one through the Great Coal-field of Bengal; and the last through the Central Range of India; so that this essay was a most valuable attempt to reduce to order, under the correcting influence of his own personal observation, the many scattered observations which had been previously made, on the structure of the Himalaya Mountains and Bengal Coal-field, but which, like the Report of Captain Herbert, having been buried in the official archives of Bengal, had been almost forgotten.

As might have been expected, Dr. Royle did not neglect Fossil Botany, and he figured in the "Illustrations" the two new genera from the Coal-field of Bengal, *Vertebraria* and *Trizygia*, the former of which is still very obscure in respect to its affinities. Connected also with his brief memoir of the Sewalik Hills, he figured some of the most interesting of their mammalian remains; and being Secretary of our Society whilst the well-known investigations into the curious fauna of that district were in progress, which have since redounded so much to the honour of Dr. Falconer and Sir Proby Cautley, he was most enthusiastic in his efforts to encourage his friends in their labour by rapidly bringing the results under the notice of men of science throughout Europe, thus performing an office which Dr. Falconer has himself so lately imitated in respect to Mr. Beekes and the Purbeck Fossils. Dr. Royle also published figures of some of the fossil mammalia from the elevated plateau of Thibet, behind the Snowy Mountains,—a matter so important in respect to the determination of the geological age of the Himalaya Chain, that it deserves the attention of every one who shall hereafter endeavour to perfect the geological examination of this magnificent and interesting region.

I am sure the Society will appreciate my feelings when I say that I have freely availed myself of the materials afforded me by Dr. Falconer (who succeeded Dr. Royle in the charge of the Botanic Garden, and was his most attached friend), not only in placing before you his geological claims, but also the following general sketch of

his truly valuable life; for who can be considered a better judge upon such subjects?

John Forbes Royle, M.D., F.R.S. & L.S., Officer of the Legion of Honour, and a Vice-President of the Royal Society, was the son of an officer in the Royal army, who had served in India. He was born in that country and educated for the medical profession in Edinburgh, where he obtained the diploma of Surgeon. He received soon afterwards an appointment as Assistant Surgeon in the E.I.C. Service, and in 1819 proceeded to Calcutta on the Medical Staff of the Bengal Army, being first attached to the Artillery at Dum-Dum. For two or three years afterwards he was moved from station to station in Bengal and the North-Western Provinces, and whilst discharging the medical duties, which the exigencies of the service demanded from him, he availed himself of every opportunity afforded by frequent change of locality to acquire a knowledge of the natural productions of the country; among which, Indian plants engrossed the first place in his attention, and drew him into correspondence with Dr. Wallich, the eminent Danish botanist, at that time Superintendent of the Honourable Company's Botanical Gardens at Calcutta. A vacancy having occurred in the charge of the Botanical Gardens at Saharunpore, Dr. Royle was, fortunately for science, selected by Government as the best-qualified candidate, and appointed Superintendent in 1823. No station in India is more happily situated than Saharunpore for the cultivation of the natural sciences. Eastward of Delhi, elevated 1000 feet above the level of the sea, near the extreme northern limit of that part of the great plain of India which is included in the valley of the Ganges, within a few miles of the Sewalik Hills, and within easy range of the great chain of the Himalayas, the position commands alike the tropical flora and fauna of the plains of India, and the temperate climate of the Snowy range, and every variety between the two. Dr. Royle possessed the acquirements proceeding from education and self-culture,—the energy of character and the ardent love of science, which at once impelled and enabled him to avail himself to the utmost of these advantages.

The Public Garden, supported by a native endowment, and laid out, after the simple native plan, with abundance of fruit-trees and common flowering plants, was entirely remodelled by the new Superintendent, after the most approved plan of English landscape-gardening; a large addition was made to the number of species grown, whether indigenous or exotic; a scientific arrangement was adopted. A conservatory was erected, an ample stream of running water was introduced, which fell into an artificial lake; in short, by many refined alterations a tame oriental garden was speedily converted into a beautifully planned and useful scientific establishment, the whole having been the creation of Dr. Royle. To compensate as much as possible for the restriction imposed upon his time by the medical duties he was obliged to perform, he despatched parties of plant-collectors in successive years to the various mountain-provinces in the neighbourhood, across the Snowy Range over the Thibetian boundary, and as far westward as the valley of Cash-

meer. By these means he amassed a rich and valuable herbarium; but his natural bent was most strongly exhibited in the investigation of the properties of plants and their application to the wants of men; and for a considerable time he supplied the hospitals of Bengal with indigenous drugs, as substitutes for the expensive articles imported from Europe. He devoted himself with great success to the identification of the articles in the bazaars of the East with the medicines familiar to the Greeks, as described by Dioscorides and Theophrastus. He investigated the agricultural resources of the plains of India, with a view to the improved culture and introduction of various grains and of plants yielding fibres and other useful products; and he endeavoured to direct attention to the capabilities of the valleys and slopes of the Himalaya for the growth of tea, which has since been so successfully carried out. Dr. Royle's principal work, "The Illustrations of the Botany of the Himalaya Mountains," is a storehouse of valuable facts and information, bearing on these and other allied subjects.

The favourable situation of Saharunpore provided other tempting fields of natural investigation, which his ardent zeal would not permit him to neglect. Single-handed he undertook the, for a tropical climate, severe task of taking hourly observations of the thermometer and hygrometer, and of the barometer on a single day in each month throughout the year, besides the regular ordinary observations twice a day; and by these means obtained excellent data for determining the meteorological conditions of the climate, and fixing one of the standard stations by which the range of mean temperature over the continent of India has been ascertained. He made collections of the mammalia, birds, reptiles, and insects of the northern plains and mountains of India, in themselves so valuable and extensive, that they furnished materials for two important and distinct memoirs by eminent British naturalists, upon the fauna of India, contained in "The Illustrations." During the various journeys through the Himalaya mountains, he carefully collected specimens of all the rocks he met with, marked the direction, and measured the inclination of the strata,—ascertained the elevation of the successive ridges, and the depressions of the intervening valleys, by barometrical measurement, and recorded the whole of the observations with such care, that, gleaned materials from other sources, and aided by Sir Henry Delabecche, he was enabled to produce a very respectable approximative geological section across the chain of the Himalayas, from the plains of Hindostan to the Snowy Range, which was brought out in his 'Illustrations.' All these varied and extensive researches were condensed within the comparatively short period of eight years. Gifted by nature with a strong frame, and a healthy constitution that never failed him, and which sickness never touched, he toiled from first to last as an earnest and ardent investigator of every natural object which came before him.

- India has not always escaped that political reaction which hurries men in authority from reckless expenditure into sordid parsimony.
- It was thus that the first Burmese and other wars had thrown the

finances of India into such embarrassment, that Lord William Bentinck was called upon to push retrenchment to the utmost possible limit. So urgent indeed was the demand upon him, that it is said he meditated the abolition of the Botanic Garden of Saharunpore; but such was the display of honest sterling work performed, and of most useful results obtained, which Dr. Royle placed before the eyes of the Governor-General, that Lord William Bentinck was spared the reproach of committing what would have been considered an act of Vandalism, and this most valuable institution was preserved,—a service for which his memory will always be regarded with gratitude by Indian naturalists.

Whilst their peril seemed to hang over one of the most cherished objects of his scientific life, Dr. Royle meditated a retirement from the service, as he could not have borne to remain in India after science had been so degraded; but as his energy, and, let it be added, the speaking testimony of his scientific labours, had averted the danger, he bore with resignation those reductions of pay and emoluments which affected him in common with other medical men, and remained in India till 1832, when he returned to Europe with a large and valuable natural-history collection. From that time to 1840 he devoted himself with characteristic energy to the investigation of the materials he had collected, and to the preparation for publication of his great work, the ‘*Illustrations of the Botany and other branches of the Natural History of the Himalaya Mountains*,’ a work which is distinguished equally by the large amount of original information it contains, and by the accurate research and comprehensive views it exhibits. On his return he became a member of all the great chartered scientific societies of London, and was named a Vice-President of the Royal Society, and latterly for several years he was Secretary of the Horticultural Society, for the welfare of which institution he felt a lively interest. The well-known ability with which he had investigated the medical botany of India, led to his appointment to the chair of *Materia Medica* and *Therapeutics* at King’s College on its first foundation; and, as a member of the Royal Asiatic Society, he, with his habitual energy, soon introduced to the notice of that learned body a new branch of inquiry, in consequence of which a committee was formed to investigate the productive resources of India. The ‘*Transactions*’ of the Society, which had been before devoted chiefly to essays on the Languages, History, Mythology, Archaeology, and Numismatics of the East, were thus enriched by a series of valuable papers on interesting commercial subjects by Dr. Royle. The interest which was now awakened in the manufacturing districts respecting the raw products of India led to so many inquiries for information, that the Directors of the East India Company were induced to establish a special department for the express purpose of spreading knowledge upon such subjects; and Dr. Royle, who had previously resigned his post as surgeon without any pension or other reward, having most wisely been placed at its head, he entered at once upon an enlarged sphere of public usefulness, suited to his great talents and vast stock of acquired information. He was instrumental

in leading to the formation of a museum at the India House, for the reception of the most important portion of the immense collections of Indian products, both raw and manufactured, which had been imported for exhibition at the great Expositions, of London in 1851, and Paris in 1855, by which the benefit and instruction to be derived from their examination will be perpetuated. To perfect this noble design Dr. Royle devoted his utmost energies, and the very day before his death, though still labouring under sickness, he attended at the Museum to urge on the work; but, alas! it was his last effort, and, suddenly cut off on the next day, the 2nd of January, 1858, in the 59th year of his age, the East India Company lost one who, whether at home or abroad, had done more than most of its servants to promote its true interests, by rendering them essentially coincident with those of mankind.

Besides the works so often alluded to, Dr. Royle published many other essays, either separately or in the Journals of learned societies, principally botanical and bearing on the medical and commercial products of plants; and it may well be said that he was eminently a scientific philanthropist. Besides his general connection with so many of the most important Scientific Societies of London, he was a Member of several Foreign Natural History Societies, amongst which may be named the Academia Caesaræa Naturæ Curiosorum; and for his exertions in rendering the Indian Collection at the Paris Exhibition in 1855 as perfect as possible, he was honoured by a first-class Jury Medal, and by the insignia of an officer of the Legion of Honour.

In reflecting on the last years of so distinguished a man, it must be a great comfort to know that he was most happy in having married a lady of highly cultivated mind, who, in the bitterness of her sorrow at the loss of her husband, has the consolation of feeling that she was the source of his greatest happiness, and a participator in his intellectual labours. He has left, besides his widow, two sons and a daughter to mourn his loss and venerate his memory; and let me add, that their feelings will be shared by the numerous friends to whom he was endeared by kindred feelings and by moral worth.

Of several of our lost members little information of any material importance can be obtained, though they have all exhibited at some period of their lives a strong desire to advance the progress of science. Mr. LAVERACK for example, while an undergraduate at Cambridge, placed himself within the circle of attraction of Professor Sedgwick's Lectures, and manifested a taste for geology by his close attendance at the Woodwardian Museum, then being put into order; but it is not known that he had any opportunity in after life of undertaking original investigation.

Mr. G. H. SAUNDERS likewise exhibited an early taste for geology, and is known to the Society as having contributed a Sketch Map intended to illustrate the position of a bed of fossil shells exposed to view in a cutting of the Panama Railway; the specimens he had

forwarded to the Society, and they were found by Mr. Moore to possess much interest in regard to the distribution of tertiary fossils over the Central American area.

Mr. FLORESI was a native of Sardinia, and ranked in his own country amongst the nobility, being Marquis d'Arcaes; but, as an Italian refugee, he only made use of his family name. For some time he was manager of a portion of the Mexican mines, which were worked under the direction of Mr. John Taylor; and he was on his way to Central America to report on mines in the Province of Guatemala, when he was attacked with fever at Panama, and died, to the great regret of his employers, by whom he was considered a most amiable and upright man. His son has since taken charge of some Mexican mines which belong to a different body of proprietors.

Mr. WILLIAM BALD was an eminent Civil Engineer and Surveyor. He was born in Burnt Island, Fifeshire, and was educated at the parish school there until he arrived at his twelfth year, when he was removed to a school at Edinburgh. After completing his ordinary education, he was apprenticed to Mr. Ainslie, C.E., of Edinburgh. He commenced his professional career in this line in 1803, and he had much experience in making railways, and in the improvement of rivers and harbours. His abilities, being fully recognized, led to his employment in Ireland, where he was directing engineer in improving the navigation of the River Boyne and in forming quays at Drogheda; and was engaged to carry bills through Parliament for the improvement of the navigation of the River Suir, and of the River Moy, both in that country. It was during the time of his residence in Ireland, that he was employed in 1811, by a Royal Commission appointed to ascertain the situation and extent of the great bogs of Ireland and the practicability of draining and improving them, and to survey and report on the extensive bogs of the county of Mayo. His reports on their situation, extent, and improvement formed part of those valuable public documents, 'The Bog Reports,' which were presented to Parliament, and printed in the years 1811, 1812, 1813. The very interesting information which these Reports contain on the peculiar condition, circumstances, and origin of the large accumulations of bog, which are so remarkable in Ireland as to constitute what may be almost considered a distinct geological formation, has caused them to be consulted by every one desirous of studying the history of bogs; and when the curious phenomena connected with them, such as the occurrence of two or three layers of tree-stumps, the "escars" or long ridges of gravel, the beds of marl, and the numerous relics of the great fossil Deer, the *Megaceros Hibernicus*, are considered, it cannot be doubted that the authors of these Reports have laid before naturalists, and especially geologists, ample materials for reflection. This was not the only great Irish work in which Mr. Bald was engaged, as he was employed about the year 1810, by the grand jury of the county of Mayo, to make a territorial survey of that county, which he afterwards completed in a most accurate and satis-

factory manner. This map was laid down and drawn on a scale of 4 inches to a mile; and I remember well my visit to the Court-house of Castlebar, some thirty years ago, to look at the map, which was then, as now, suspended in a large room, and justly considered a topographical work of the very highest order. That the triumph it then achieved was well-merited, may be judged from the honourable testimony which that able judge, Sir Richard Griffith, Bart., known to us all as one of our oldest and most able members, has recently borne to its excellence in the following words addressed to me on the subject:—"Though slightly faded, the mountain-ranges, hills, and other, even very minor, features of the country have been so carefully and faithfully represented by drawing and shading, as to present one of the most striking and effective maps I have ever seen on so large a scale, and in pictorial effect little inferior to the magnificent map of the mountains of North Wales, long since executed by Mr. Dawson, father to the present Colonel Dawson, R.E." This warm and frank expression of approbation, bestowed by a Civil Engineer of such eminence as Sir Richard Griffith, himself the author of the highly-valued Geological Map of Ireland which will long be an object of emulation to the Government Geological surveyors, to his former associate and acquaintance, seems peculiarly appropriate, as it is not too much to say that the map of Mr. Bald was in its time a fitting object of emulation to the Government National Surveyors, whether Engineer Officers and men, or Artillery Officers for some time associated with them, or Civilians who formed so large a portion of their hard-working staff, although it is much to be feared they shared more in the labours than in the honours and advantages of their military comrades.

Independently of the merits of his map of Mayo, Mr. Bald deserves to be remembered with respect by the Officers of the Ordnance, or, as it should now be called, the National Survey, for the manly and frank manner in which he gave his evidence in their favour, when the propriety of confiding the charge of the Irish Survey to the Ordnance was under discussion before a Committee of the House of Commons. The opinions of Civil Engineers and Surveyors were much divided; but Mr. Bald allowed no private interests to blind him to the advantage of a uniform system, carried on with the regularity and precision which military discipline enforces and ensures: but, while I say this in justice to the liberality of Mr. Bald, let it not be supposed that I am the advocate of monopoly or exclusion in any department of the public service.

When Mr. Bald left Ireland, he was employed for a time as a draftsman at the Admiralty, and then, by the Corporation of Glasgow, as Engineer for the improvement of the navigation of the Clyde by the erection of embanking-walls to circumscribe its channel, and by dredging to deepen it—reports of which operations were drawn up by him and printed. He was in this manner the recognized Resident Engineer to the Trustees of the River Clyde from 1839 to 1845, in the summer of which year he was engaged by the Chamber of Commerce to examine the River Seine in France, from Havre-de-Grâce

to Rouen. I have been unable to learn anything of the last years of Mr. Bald's life, and I must therefore here close my remarks upon a man, whose talents, which reflected so much credit upon his profession, were employed on objects both useful and interesting to geologists.

The very eminent Mineralogist and Crystallographer, HENRY JAMES BROOKE, was born at Exeter on the 25th May, 1771, his relatives being engaged in the manufacture of broad-cloth; and after having received an ordinary scholastic education, he studied for the Bar, but was induced from the favourable prospects which appeared before him, to abandon that profession and to engage in the Spanish wool-trade in London, for which object he spent nearly two years in Spain: it is, however, justly asserted that the active study of the law had, like that of mathematics, the effect of framing his mind to precise habits of thought and expression, the effects of which became apparent in all his subsequent acts and observations. In the year 1812, soon after he had become a resident of London, he turned his attention to the subjects of Mineralogy, Geology, and Botany, but more especially to the two former sciences, for which he had a peculiar predilection. He was elected a Fellow of the Geological Society in 1815, of the Linnean in 1818, and of the Royal in 1819, on the Council of which Society he served in 1842-44. Though devoting his leisure hours to scientific pursuits, Mr. Brooke did not neglect his ordinary duties, and assisted the late Mr. Henry Hase, Cashier of the Bank of England, in establishing the London Life Assurance Association; and, as the Spanish wool-trade began to decline, Mr. Brooke sought a pursuit more congenial to his taste in the establishment of companies to work the mines of South America; but, as these undertakings were too often marred in their prospects of success by difficulties abroad, he accepted the office of Secretary of the London Life Association, in forming which he had assisted; and after several years' service, such was the appreciation of the advantages he had conferred on that body, that on his retirement a liberal annuity was granted to him by the society.

Though interrupted for some time in the pursuit of his favourite sciences, by the consequences of a serious accident he experienced by being knocked down by a horse suddenly turning a corner near his residence, Mr. Brooke was not a man to be satisfied with idleness, and for recreation's sake he formed a large collection of shells, which he afterwards presented to the University of Cambridge. Not thinking the study of the simple envelopes of organic bodies sufficiently intellectual, he then took to the collection of engravings, having himself early in life made considerable progress as an amateur artist; and some specimens of rare excellence were presented by him to the national collection in the British Museum. This interruption of his scientific labours was only of short duration, and being usually blessed with excellent health, he continued to pursue his favourite studies with unabated activity until a short time before his death on the 26th June, 1857, at the good old age of 86 years.

Of his works, the 'Familiar Introduction to Crystallography' was the first systematic treatise which in this country brought that delightful branch of science into notice: it was based on the system of Haüy, and adopted therefore an unnecessarily large number of primary forms: but at the same time the relations of the various existing plane surfaces of crystals were traced out with a clearness which was a great improvement on preceding systems. In the subsequent Treatise on Crystallography, published in the 'Encyclopædia Metropolitana,' Mr. Brooke simplified the former one, and reduced the number of primary forms to six, which correspond with the six systems adopted by Continental Crystallographers. Mr. Brooke discovered and described thirteen new mineral species.

Mr. Brooke applied the reflective goniometer to the determination of the crystalline forms of artificial salts, and in the 'Annals of Philosophy' for 1823 described no less than fifty-five laboratory-crystals thus determined. He was the author of the article "Mineralogy" in the 'Encyclopædia Metropolitana,' and was associated with Professor W. H. Miller in the reproduction of the well-known treatise of the late Mr. Phillips. His last work was on the general relations and geometrical similarity of all crystals belonging to the same system; it formed the subject of a paper read before the Royal Society, and was in the press at the time of his decease. With a liberality equally characteristic both of Mr. Brooke the elder and the younger, the valuable and almost unique collection made by the father during half a century, has been presented by the son to the University of Cambridge,—a generosity which has wisely adopted the most efficient method of perpetuating the memory of a man who had so successfully endeavoured to simplify the study of that branch of Mineralogy which of all others is most full of interest; for assuredly crystallization seems to afford a sort of link between organic and inorganic nature, by showing that not only in composition, but also in external form, lifeless and inert matter has been subjected to definite laws by creative Intelligence and Power.

FRANCIS, EARL OF ELLESMERE, a Knight of the Garter, Lord-Lieutenant of Lancashire, and during the year 1854-5 President of our sister Society, the Geographical, was one of those eminent individuals who in our day have shed lustre over the high order of nobility to which they belong, by their literary and scientific acquirements, just as their ancestors, in olden time, did by martial qualities. It is indeed a characteristic of the present age, which is principally due to the establishment of societies devoted to special branches of scientific inquiry, that men of the highest social position do not disdain to emulate men of a lower grade in the endeavour to obtain the first places in the ranks of science. Lord Ellesmere was the second son of the first Duke of Sutherland, and of that gifted lady the Duchess Countess of Sutherland. He was born in 1800, and died on the 18th February, 1857, being therefore cut short in his distinguished career at the comparatively early age of 57. As a geographer of a high order, Lord Ellesmere has received an affectionate and

eloquent tribute from the pen of our own Sir Roderick Murchison, the President of the Geographical Society, in his Annual Address to that most useful and prosperous Society; and I can do no better than glean from him what is necessary to justify the high estimation in which we have always held that estimable Nobleman.

For a large portion of his writings, Lord Ellesmere adopted the Quarterly Review as the medium of communication to the public. It appears that between the years 1834 and 1854, he was the contributor of no less than fifteen articles, many of which were directed to geographical research, others to the fine arts of which he was an able connoisseur, and some to biography, or to military exploits, as the spirit of chivalry was as alive in him as in the breasts of his warlike ancestry. His accounts of the works of the Dutch authors Meiglan, Fischer, and Doëff, and especially his vivid picture of the manners and usages of the Japanese, have been justly praised as having thrown a charm over geographical science, and rendered even its minute details attractive. The lively interest he displayed in the romantic expedition of Sir James Brooke, his analysis of Arctic and Antarctic researches, and his account of the travels of Castron among the Japps not only prove the pleasure he derived from perusing the narratives of voyagers and travellers, but also his ability in estimating the value of their results. Many must remember the stately figure, and the courtly yet courteous manners, of this type of the true English nobleman, when, opening the halls of the palace of his family for the reception of the leading men of science, he collected, as it were, the living gems of intellect within a frame-work enriched by those of past ages as displayed in his rich collection of the works of the great masters of art; as well as the dignified manner in which he presided over the Geographical Society: he exhibited indeed every quality which is calculated to adorn a nobleman of such high social position, and to render him a fitting leader of his fellow men. The versatility of his talents has been already noticed; but it may be added that he possessed the soul of a poet; for who but a poet could attempt to transfuse the spirit of a Goethe and Schiller into the English language?—and unquestionably the soul of a soldier, as, in addition to the papers in the Quarterly Review, he translated ‘Clausewitz’s Campaigns in Russia,’ the ‘Sieges of Vienna by the Turks,’ and the ‘Last Military Events in Italy.’ This latter aspect of his character was strikingly marked by the strong attachment and respect he always manifested for the great Duke of Wellington; and his singular ability for military science may be judged from the sound judgment he has exhibited in his Preface, or, as it may be called, Introduction to Clausewitz’s “Campaign of 1812.”

His thorough knowledge of the fine arts is well known; and his general acquaintance with science, as well as his earnest desire to apply it to the practical amelioration of the condition of his fellow creatures, was publicly manifested by his address to the British Association, over which body, at its meeting in 1842, at Manchester, he presided as President, being then Lord Francis Egerton. His generous support of men of genius, and his domestic virtues, flowed

from the highest qualities of the human heart; and I need do no more than quote the expressive words of one of his intimate friends, as given by Sir Roderick Murchison:—"His calm exterior and tranquil manner covered a deep-seated enthusiasm for the honour of his country, for the progress and amelioration of his species, and for all that is grand and noble in sentiment or in action."

REAR-ADMIRAL SIR FRANCIS BEAUFORT, K.C.B., D.C.L., F.R.S., F.R.G.S., CORR. INST. FRANCE, was one of those remarkable men who in these days have afforded to the world a most powerful illustration of the fact, that the highest cultivation of the intellect is quite compatible with the nautical knowledge and habits which enter into the composition of a first-rate seaman and an able navigator. If indeed the example of Lord Ellesmere has shown how much the highest order of nobility may be adorned and elevated by scientific and literary tastes, we may also affirm that much of the dignity which has been associated with the names of Beaufort and of Graves, and with those of Admiral Smyth and Captain Sprat, fortunately still living, and of many other illustrious seamen and navigators, is due to the happy combination in their characters of high scientific attainments and of great practical skill.

Francis Beaufort was born in 1774, and was an Irishman of French extraction. His father, the Rev. Daniel Augustus Beaufort, was Vicar of Collon, in the county of Louth, and was directly descended from an ancient and noble French family. Francis was the second son, and the heir of some of the talents and tastes of his father, who numbered amongst his good deeds the best map of Ireland, previous to the Ordnance Survey, and an able Memoir on Ireland; but it may be added that those who have read the able essay upon the Round Towers of Ireland by one Miss Beaufort, and the kind-hearted and cheerful books written for the benefit of children by the Misses Beaufort, who are so well known and so highly appreciated in Dublin, must further acknowledge that the tastes and virtues of a whole family were embodied in the Admiral.

Though only thirteen when he went to sea, Francis had already many of the requisites of an able officer. On his first voyage, which was with Captain Lestock Wilson, in the 'Vansittart,' East India-man, as a "guinea-pig"—that is, in virtue of the payment of a hundred guineas,—he was remarkable for his skill in observation, and the amount of his nautical knowledge; so that he afforded valuable assistance to his commander in surveying the Strait of Gaspar, in the Sea of Java. His perilous adventures began thus early. The survey was just completed when the 'Vansittart' struck upon a rock off the Island of Banca (not very far from the spot where the 'Transit' went down last autumn), and through the hole stove in her bottom daylight and sea poured in alternately. An effort was made to keep the ship afloat until the flat shore of Sumatra could be reached; but even the hope of a landing on Banca was presently given up, and she was run aground on an island seven miles from Banca. The crew escaped in the boats, and, with the loss of six

lives and one boat, reached two English ships after five days' rowing, with great suffering, on the open sea, close to the line. This adventure happened in August 1789.

His name had already been for two years on the books of His Majesty's ship 'Colossus'; but on his return from the East he joined the 'Latona,' Captain Albemarle Bertie, and afterwards the 'Aquilon,' in which he was engaged in the memorable action off Brest, of the 1st of June 1794, during which ten of the enemy's ships were dismasted and seven taken, and after which Lord Howe brought into Portsmouth six French ships of the line, which the King and Royal family came to inspect at the end of the month. They went on board the 'Aquilon' to sail round the fleet, and thus young Beaufort made, probably, his first acquaintance with royalty. He was for some years the sole surviving officer of that great battle. He followed his captain, the Hon. Robert Stopford, to the 'Phaeton,' in which ship he was serving when Vice-Admiral Cornwallis made his celebrated retreat from the French fleet on the 17th of June 1795. In this ship, afterwards commanded by Captain James Nicholl Morris, he assisted at the capture and destruction of many of the enemy's ships, and of nine privateers and other vessels. It was in May 1796 that he obtained his rank of Lieutenant, and in October 1800 that his first great opportunity of distinguishing himself occurred. While cruising off the coast of Malaga his commander observed that a Spanish polacca, the 'San Josef,' and a French privateer brig, had taken refuge under the fortress of Fuengirola; and at night the young lieutenant was sent in command of the 'Phaeton's' boats to board the 'San Josef.' The French brig intercepted the launch; but the other crews did their work without its aid. The resistance they encountered was desperate; but they obtained their prize, with the loss of one man to thirteen of the enemy, Beaufort, however, receiving no less than nineteen wounds. This made him a commander, with a small pension.

The two next years were spent on shore, but not in idleness. Miss Edgeworth tells us that they were "devoted, with unremitting zealous exertion," to establishing a line of telegraphs from Dublin to Galway, an object of great importance as long as the west of Ireland was perpetually liable to invasion from continental enemies. He received the thanks of Government for his efforts, declining any other acknowledgment.

Once more at sea, he was heard of from the East first, and then the West. As commander of the 'Woolwich,' 44, he convoyed from India sixteen Indianmen in 1806. In 1807 he was surveying the River La Plata; and he afterwards went to the Cape and the Mediterranean. In 1809 he was hovering about the enemy's merchantmen on the coast of Spain and at Quebec, being in command of the sloop-of-war 'Blossom.' In 1810 he obtained his post rank, and the command of the 'Fredericksteen' frigate; but before he joined he was employed in protecting the outward-bound trade to Portugal, Cadiz, and Gibraltar, in accompanying two Spanish line-of-battle ships to Minorca, and in acting for some months as captain to the

'Ville de Paris,' a first-rate, in the fleet off Toulon, commanded by Sir Edward Pellew.

It does not appear to be on record in which year of his life it was that he so nearly perished by drowning, and underwent the remarkable experience of the intellectual condition under such a crisis, which he afterwards recorded in a letter, at the request of Dr. Wollaston. He described himself as "a youngster, at Portsmouth, in one of the King's ships." He was not himself impressed as others were by the remarkable character of his sensations; but he saw the importance of every such record, and made it accordingly. Interesting in itself, the story is extremely valuable as coming from one as singularly truthful in recording experience as skilled in detailing it. One of his most striking accomplishments was the power of expressing what he meant. The effect of this power was seen wherever he went, in the harmony he seemed to establish by the clearness of his ideas, and the graphic manner in which he expressed them. All the disputings and perplexities which accompany the rule of men of confused mind and speech were extinguished by Beaufort's mere presence; and he at once made every one aware of their own, as well as of his views and objects.

This power of rendering the most abstruse subject easy of comprehension, a power possessed by very few, was strikingly exemplified in the letter to Wollaston, published in Sir John Barrow's Autobiography, which describes that peculiar psychological condition of the human frame at times when it hovers, as it were, between life and death, or is on the point of yielding up the united existence of body and soul, and assuming that alone of the soul. Few have doubtless experienced this condition under the same circumstances as Admiral Beaufort, by being snatched from drowning at the very moment when the soul was about to assume its undisputed empire; but many have passed through a corresponding state at times when, fever having reduced the powers of the body to a *minimum*, and elevated those of the soul to an unnatural and unbalanced sway, sleep is dispelled from the weary eyelids of the body, and the phantoms of past words, thoughts, and acts come rushing unbidden, and too often, unwelcome, upon the mind's eye. At such moments the past is reflected upon with pain or with pleasure, in proportion to its relation to evil or to good, and doubtless in reference to its bearing upon the future; and hence the natural reflection of Admiral Beaufort,—

"May not all this be some indication of the almost infinite power of memory with which we may awaken in another world, and thus be compelled to contemplate our past lives? or might it not in some degree warrant the inference that death is only a change or modification of our existence, in which there is no real pause or interruption? But, however that may be, one circumstance was highly remarkable—that the innumerable ideas which flashed into my mind were all retrospective. Yet I had been religiously brought up, my hopes and fears of the next world had lost nothing of their early strength, and at any other period intense interest and awful anxiety would have been excited by the mere probability that I was floating

on the threshold of eternity; yet at that inexplicable moment, when I had a full conviction that I had already crossed that threshold, not a single thought wandered into the future, I was wrapt entirely in the past." In several passages of the deeply interesting statement of Admiral Beaufort will be observed an idea which was afterwards powerfully elaborated by Mr. Babbage in the Ninth Bridgewater Treatise.

When he took the command of the 'Frédéricsteen,' in 1811, he was on the road to fame as an author. Sir J. Barrow tells us that Beaufort was selected out of the whole Mediterranean fleet to survey an unknown portion of the coast of Syria. The result of this errand was, not only a capital survey, but a historical review of the country, as illustrated by its remains of antiquity. Beaufort's 'Karamania' was, as a book of travels, sound, substantial, and learned (thanks to the good classical education his father had given him), and full of interest at once for the man of science and the scholar. It was this book, with its discoveries and verifications of ancient sites, which had prepared the way for the researches of Fellows, Spratt, and Forbes, and more recently of Charles Newton, in Asia Minor, the result of which has been that the Halicarnassian Marbles have become part of the treasures of the British Museum.

After much hazardous service against the pirates in the Greek waters, Captain Beaufort went to work on the survey of Syria, in the course of which he underwent extreme danger. In June 1812, his party was surrounded by armed Turks led by a crazy dervish, and he was wounded in the hip-joint so seriously that the wonder was that he ever walked again. It was a severe struggle for life itself; and when his ship was paid off, in the next October, he was still undergoing much pain from the exfoliation of the bone. He solaced his enforced leisure by work, preparing for the Admiralty such a set of charts of the coasts of Asia Minor, the Archipelago, the Black Sea, and Africa, as had never before been seen at the Admiralty. They were so drawn, finished, and arranged as to be fit for transference to the copper without any aid from the hydrographer or his assistants. Such is the testimony of Sir John Barrow, who recommended him to Lord Melville for the post of Hydrographer.

This was in 1829. In 1823 Captain Hurd had died, and Captain Parry was requested by Lord Melville to fill the post temporarily, which he did twice, if not three times. After the resignation of the Duke of Clarence as Lord High Admiral, Lord Melville again became First Lord, and one of his objects was to fill the office of Hydrographer with the best man that could be found, who should hold it permanently. There were many applicants; but by 1829 two names only remained for choice—and one of them was not an applicant, Captain Peter Heywood. Lord Melville therefore requested Sir John Barrow and Mr. Croker to advise him. Sir John Barrow had, as we have seen, selected Beaufort out of the whole Mediterranean fleet for the survey in Asia Minor; and that survey having been so ably completed, he naturally named for the office of Hydrographer the accomplished officer who had so much distinguished himself.

For twenty-six years Beaufort was at the Admiralty as Hydrographer; and very early in that period he had made his office the model on which Copenhagen and St. Petersburg constructed theirs. Everywhere hydrography took a new form and existence, through the life which he put into his work. There is not a geographical discoverer, nor a zealous professional student in any naval service in the civilized world, who does not feel under direct obligation to Beaufort for his scientific assistance given through his works, or more special encouragement by his personal aid and counsel: those, indeed, who remember the enthusiasm with which Commander Wilkes, of the United States Exploring Expedition, used to speak of the friendly assistance afforded by Captain Beaufort, in preparing for that important enterprise, cannot doubt of the appreciation in which he was held by his professional brethren of all nations.

It has been no small benefit to the world that the most accomplished hydrographer of his own or any time was at our Admiralty for six-and-twenty years, always ready to avail himself of any chance of increasing general knowledge, and ever genial and generous in assisting every man of any nation who devoted himself to geographical discovery or the verification of glimpses already obtained. His name is attached to several stations in newly-discovered lands and seas; for instance, it will be uttered in all future times by voyagers passing up either the eastern or western shores of the American continent to the Polar Sea; but even when not expressed, it is invisibly connected with almost every other modern enterprise of geographical discovery; for he gave a helping hand to every scientific adventurer who applied to him, and no one thought of instituting scientific adventure without applying to him.

When he entered the Admiralty, nearly thirty years ago, he found his own department a mere map-office. His friends well remember what a place it was—small, cheerless, out of the way, altogether unfit and inadequate. The fact is, nobody but the *élite* of the naval profession had any conception of the importance of the office—of the true functions of the hydrographer. Maritime surveying on an extended scale was only beginning. We were not yet in possession of the full results of the labours of Flinders, Smyth, King, and Owen; and Sir Edward Parry's view of his office was, that it made him the Director of a Chart Depôt for the Admiralty, and the supporter, rather than the guide or originator, of maritime surveys. Becoming conscious that the times were requiring something more than he could give, he wisely resigned. The manner in which Captain Beaufort was appointed, without solicitation on his own part, and simply because the best judges considered him the fittest man, encouraged him to lay large plans, and to indulge high hopes. He began a great series of works, in which he intended to comprise, gradually and systematically, all the maritime surveys of the world, —our own coasts, still shamefully obscure, being destined for a thorough exploration in the first place. He designed and began what Lieutenant Maury has since achieved. His instructions to surveying officers show how extensive were his purposes as to deep-

sea soundings so long ago as 1831; and the object was never lost sight of, though he was baffled in the pursuit of it. Whatever depended on his own energy was done, throughout his whole term of office; but he had to endure the affliction, often experienced by highly qualified servants of the Government, of not being able to excite a sympathy in his views amongst those in power, or amongst those who, keeping watch over the public purse, sometimes arrest the progress of what would conduce to the public interest. It is indeed no small mortification to compare our Hydrographical Establishment with that at Paris, where the *Dépôt de la Marine* might be taken for the office of the greatest maritime power in Europe; or with those at St. Petersburg, Copenhagen, and Washington; but the annual amount of shipwrecks, and the number of lives lost through want of that knowledge which Beaufort would have established a quarter of a century ago, gave rise to a severer grief, which weighed heavily on his heart, and was probably the most painful experience of his life. The universal spread of education, and the more scientific tone which it has assumed, will, it is hoped, rectify this evil, by satisfying the Members of Government, as well as our Legislators, that expenditure on such objects can never be money thrown away; and we trust therefore that the able successor of Beaufort, Captain Washington, to whom I am indebted for most of the materials of this memoir, will be secured from the anxieties and mortifications which his predecessor experienced.

Captain Beaufort was so restricted in his office that he had no subordinate who could be a comrade in his labours; and all that he had at heart was done by his own hand. Disappointed in some of his hopes, and pinched in his official expenditure, he applied the full forces of his strong will to make the best of the hard circumstances of the case. His industry, of constitutional origin, and sustained by principle, appeared something miraculous under this stress. Day by day for a quarter of a century he might be seen entering the Admiralty as the clock struck; and for eight hours he worked in a way which few men even understand: for many years he rose at five, and worked for three hours before his official day began. The anecdote of his connexion with the maps of the Society for the Diffusion of Useful Knowledge has recently gone the round of the newspapers; and all the world knows that, in order to get these maps sold at sixpence instead of a shilling, he offered to superintend their preparation. As if he had not enough to do in his own function, he gave the world that set of maps, so valuable that no ship in the United States navy is allowed to sail without them; and it is his doing, that they are in a thousand houses which they would never have entered but for their cheapness.

This is one of his innumerable charities. There was no sort of charity in which he was not just as liberal and as wise. There was no pedantry in his industry, any more than in his knowledge. He never seemed in a hurry. While too seriously engaged for gossip, he had minutes or hours to bestow where they could really do good; he had conscientious thought to spare for other people's affairs, and

modest sympathy in their interests, and intrepid advice when it was asked, and honest rebuke when it was deserved and might be effectual. His unobtrusiveness was perhaps the most striking quality of his manner, to observers who knew what was in him. His piety, reverent and heartfelt, was silent, as he preferred that that of others should be. His domestic affections were unconcealable; but spoken sentiment was quite out of his way. His happy marriage (with the daughter of his first commander, Captain Lestock Wilson) ended in a mingling of pain and privilege which touched the hearts of all witnesses. Never was so much understood with so little said. She died of a lingering and most painful disease, making light of it to others as long as possible, though the full truth was known to both; she kept her young children about her, with their mirth wholly unchecked, to the latest possible day; and the few who looked in on that sacred scene saw that it was indeed true that, as she said, she had never been happier than during that painful decline. As for him, there was not the slightest remission of public duty, while his domestic vigilance so powerfully assisted in soothing her passage to the grave. Now that both are gone, it is right to present this feature in the character of the man so long before known as hero and as *savant*. He came out from the long trial so much changed that it seemed doubtful whether he would ever regain his health and buoyant cheerfulness. He lived, however, to see his children fulfilling, each his own career of labour and honour: one son in the church, another as Legal Remembrancer (Attorney-General) in Calcutta, and a third as a judge in Bengal. By his second marriage, with a sister of Maria Edgeworth, he secured a friend to himself and his daughters for many of the latter years of his life.

Among his public labours were those of the successive offices of Commissioner of Pilotage, entered upon in 1835, and of Member of the Royal Commission to examine into the state of the Tidal Harbours in the United Kingdom, in 1845. In 1846 he became Rear-Admiral on the retired list rather than surrender his office; but he never liked his "yellow flag," and the mortification of his retirement was but slightly solaced by the honour of the Knighthood of the Bath, conferred in 1848. The sudden expansion of railway-projects so increased his work that his health began to fail, but not till he had reached an age at which few men think of work at all. Early in 1855 he was obliged to retire and go home to a sick bed to suffer with fortitude the pangs of a painful and incurable disease. He was the same man to the last,—active and clear in mind, benevolent and affectionate at heart, and benign in manners. His activity never interfered with his profound quietude and peace; and his quietude and peace deepened, as his mind brightened, to the last.

He was short in stature; but none of those who were personally acquainted with him will forget his countenance, which could nowhere pass without notice. Its astute intelligence, shining honesty, and genial kindness revealed the man so truly that, though he never lauded himself, few were so correctly estimated, and so highly valued. He was attended in his last hours by his adoring children, and died

in the midst of them on the 17th of December, 1857. Whilst deploring his loss, society should be thankful that such a man was spared so long for the benefit of mankind. Although most of the preceding record is but the echo of the tribute already paid to this great man by one of his most distinguished friends, I have thought it due to the members of this Society to preserve it that they all may be able to dwell on the character and merits of one who has shed so much lustre on this and other scientific societies. May the officers both of army and navy be encouraged to imitate so bright an example, and not be deterred from doing so by the senseless dread of becoming *too learned*!

THOMAS BEST JERVIS, Lieut.-Colonel E.I.C. Engineers, F.R.S., F. Geol. S., F. Ast. S., F.L.S., F.A.S., F. Geog. S., M.I.C. Eng., Cor. M.N.H.S. Boston, Soco. Ethnogr. Paris, &c. &c., was the second son of John Jervis, Esq., civil servant of the E.I.C., who, having for some time held a high post at Madras, was transferred to Jaffnapatam, on the north of the island of Ceylon, where Thomas Best Jervis was born, August 2, 1796. Lieut.-Col. Jervis throughout life valued himself less upon his ancestry, although his family is most ancient and respectable, than on the fact that several of his relatives had been eminent for their patriotism, learning, and integrity. The head of the family, James Jervys, Esq., possessed the property of Chatkyl, in Staffordshire, in the fifteenth century; and Colonel Jervis would recount with satisfaction the fact of King Charles having been protected and hidden after his retreat to the oak, by Miss Lane, one of the staunch royalist members of the family. In later times the celebrated divine, Bishop Hooker, and the Earl of St. Vincent (Sir J. Jervis), have nobly maintained the honour of the family. On his mother's side Colonel Jervis was descended from a Polish family of the name of Ritzo, who had been for generations in the royal household of the Georges, whom they accompanied from Hanover. Baron Grimm's family still reside in Prussia, where the present Dr. Grimm is physician to the king of Prussia, and one of the principal medical officers of that country.

George, Thomas, and John, the three sons of Mr. John Jervis, were sent home to England at a very tender age, in accordance with the necessity imposed by the tropical climate, for their education, and were consigned to the care of their uncle Chief-Justice Thomas Jervis, of the Chester circuit. Thomas was first transferred to a maiden aunt, Miss Jervis, at Lichfield, an excellent Christian person, from whose watchful care he acquired that deeply-rooted principle which was always one of his most marked characteristics. The first school he went to was kept by a *Dame*; and, being there taught along with little girls, he was thoroughly grounded in English grammar, and other subjects too often neglected or omitted at boys' schools. From hence he probably derived an habitual gentleness of disposition, so that he had an uncommon tenderness of feeling, even towards the brute creation, never liking to inflict pain even on an insect. From Lichfield he was placed at a school at Rugely (Staffordshire), and subsequently sent up to town to Judge Jervis, whose wife, having children of her own, always

treated the three "India boys" with comparatively little ceremony. Thomas was sent to Mr. Delafosse's excellent classical school at Richmond, and, having to trust entirely to his own exertions for getting on in life, early showed an eager thirst for knowledge; so that, instead of wasting his youth in play, he studied with the greatest attention, and was soon one of the most proficient in the school for his classical knowledge, taking great delight in Greek and Latin poetry. He now became very desirous of acquiring a knowledge of other subjects then so much neglected at classical schools, as is still too frequently the case in great seminaries: he procured some books on elementary mathematics, and studied them diligently, making himself by his zeal a favourite with the principal. During the holidays, which he spent with his uncle, he still pursued his studies by himself, and spent his allowance of pocket-money in procuring little French books, a pencil, or something similar, exhibiting an energy in the pursuit of knowledge uncommon in a lad of his age, though shared in a measure by his two elder brothers. He now persuaded his cousins to teach him a little French and drawing; and he always remembered with gratitude the simple lessons of one of them who thus assisted him. Hence he was sent to Addiscombe College to study for the East India Company's service, in which for several generations his family and relatives had passed the best years of their life. He had here a better opportunity of studying the languages, French, Hindustani, &c., and under the able professors of that establishment he mastered the elements of mathematics, becoming, as he advanced in knowledge, enraptured with the subject, which he followed up to the day of his death with unwearied delight. After having remained the requisite time, he passed a most honourable examination for the Engineers, being one of the foremost of the cadets of the year (and there was no lack of talent among the candidates for the Engineer service); and he was sent to Worcestershire, under Colonel Mudge, R.A., to work on the Ordnance Survey of England: the part he surveyed was the town and neighbourhood of Bromsgrove, since engraved on the 1-inch scale.

He now embarked in the fleet which was despatched to convoy the merchantmen sailing for Bombay, and he arrived at that port in May 1814. Immediately after his arrival he entered on the responsible duties of his profession, and had the control of large sums of money, £28,000 having been spent by him in erecting civil and military buildings; and at one time he had five thousand natives under his orders, whom he had to instruct in bricklayers' and masons' work. To make up for the scarcity of limestone, he examined the beach, and, finding that there was a considerable bed of recent shells in the neighbourhood, he persuaded old women and children and infirm villagers, by liberal offers, to collect them in baskets; and so great was the quantity obtained, that the kilns were filled and the building rapidly erected. He was appointed interpreter to Major-General Keir, in Guzerat, in December 1817; temporary Assistant to the Superintending Engineer at the Presidency in February 1819; and Executive Engineer, Southern Concan, in September 1819.

In 1820 he requested to be appointed to survey the Southern

Concan. The Chief Engineer considered "the offer creditable to the activity of the officer;" and Lieut.-Colonel Kennedy recommended that he should be permitted to commence on the proposed undertaking, as being in all respects highly qualified for executing such a work; and the Governor in Council authorized his being employed in making the survey whenever he could be spared from his other duties as Executive Engineer. He was thanked by letter on the 5th December 1820, by Mr. Pelly, the Collector and Magistrate in the Southern Concan, for the admirable internal organization of his department, and was then placed at the disposal of the Commander-in-Chief, to be employed on an expedition against the pirates in Arabia.

His Report on Weights and Measures was noticed as "highly creditable to his talents and philosophical researches," and obtained a special acknowledgment from the Government, dated July 1822, which expressed their approbation of the ability and research it displayed.

In 1824 Lieut.-Colonel Sutherland, Deputy Surveyor-General, bore testimony to the value of Lieut. Jervis's services as a Trigonometrical Surveyor, and in the same year the Government expressed its approbation of the "zeal and diligence he had displayed in the preparation of certain Revenue and Statistical papers;" and in June 1826, noticed in terms of approbation his "able and intelligent Report on the State of Education in the Concan."

In 1829 the Commander-in-Chief (Sir Thomas Bradford) submitted to Government, Captain Jervis's application to be appointed Deputy Surveyor-General of India, on the death of the Surveyor-General, with his Excellency's warmest and most unqualified recommendation that it should be complied with. "Captain Jervis," his Excellency adds, "was employed under the late General Mudge, from whom he has the highest testimonials, in the grand Trigonometrical Survey of England in 1812. His Excellency conceives him to be the most qualified person that could possibly be selected for the situation to which he aspires."

He was appointed Inspecting Engineer of the Surat division in December 1829; Superintending Engineer at the Presidency in 1830; in the same year Acting Inspecting Engineer in Guzerat; afterwards Executive Engineer in Ahmednuggur, and Acting Executive Engineer in Belgaum, in March 1831.

The Government expressed their satisfaction at the zeal and energy he had displayed in prosecuting his researches, and for information he had afforded respecting slate-quarries discovered in the Southern Mahratta country. In 1833 the church built by him at Belgaum was stated to reflect great credit on his taste; and the following extract from a letter addressed to Captain Jervis, dated 8th August, 1831, will show the high estimation he had then acquired:—"The Governor in Council, highly appreciating the value of your labours, and desirous of securing to the Government and the public all the benefits that can be derived from them, accepts your offer to prepare a copy of your Statistical Memoir of the Concan in a complete state and form for publication."

In February 1835 the Government reported that Captain Jervis had completed his statistical reports and memoir on the revenue-system of the Concan, and had furnished a volume of beautifully executed maps and plans, "which reflect great credit on him." In 1835 also the acknowledgments of Government were conveyed to him for his "curious and interesting volume on Weights and Measures;" and the Governor in Council stated that he considered Captain Jervis deserved great credit for having devoted his spare time and distinguished talents to the illustration of so difficult a question..

He was appointed Superintending Engineer at the Presidency in May 1835; and member of a committee to take into consideration the best plan for the construction of a causeway between Bombay and Colaba in October 1835; and the Government subscribed for fifty copies of his Statistical and Descriptive Memoir of the Western Coast of India.

On his quitting India on furlough to Europe in 1836, Government expressed "the high sense which they entertained of his character, professional skill, and talents. Before his departure he drew up a code of instructions, at the request of Sir Thomas Bradford, the Commander-in-Chief, in three languages,—English, Hindustani, and Mahratta. In 1837 the Court of Directors awarded him a donation of 10,000 rupees as a testimony of the high sense which the Court entertained of the value of his labours in conducting the geographical and statistical surveys in the Concan. In 1838 the Court expressed their approbation of "the zeal evinced by him for the advancement of the objects of the Survey of India by making himself fully acquainted with the details of the system which is pursued upon the Irish Survey;" and about the same time he was appointed to superintend a series of tide-observations to be made upon a uniform principle at various points of the coast of India. He returned to his duty in October 1839, and was appointed Superintending Engineer, Northern Provinces, in March and May 1840.

On his retirement from the service in December 1841, the Governor in Council stated that "he will have much satisfaction in bringing to the notice of the Court of Directors the services of Major Jervis in the several branches of his particular profession, and also as an officer eminent for his general science and research;" and the testimony borne to his services by the Bombay Government was creditable to him and most satisfactory to the Court of Directors.

In 1830 Captain Jervis married Miss A. S. Paget, daughter of William Paget, Esq., M.D., 48th Regiment; and this lady, having been the intimate friend and coadjutor of Mrs. Ibbetson the botanist, was an able assistant to Captain Jervis in his description of the indigenous flora of the Concan, as she made water-colour drawings of almost all the flowering plants and trees of the Province: the work he then projected has not however been published.

Whilst in London, Major Jervis drew up a statement of the scientific researches which he deemed to be desirable in Shedda; and this comprehensive report was considered so valuable and so important, that a memorial was addressed to the East India Company

on the 14th of July 1838, signed by His Royal Highness the Duke of Sussex, as President of the Royal Society, and many of the most illustrious members of that and other Societies, urging that the Government in India might be directed to forward in every possible way his views; and no one expressed himself with more characteristic and generous warmth in his favour than Sir Roderick Murchison. About this time Major Jervis had been appointed Surveyor-General of India in succession to the present Colonel Everest; but, finding after his return to India that that officer had no intention to retire so soon, he gave up his hopes of being ever able to carry out his favourite project, and retired, as has been stated, from the service, in January 1842.

Whilst in India his discovery, and application to useful purposes, of lithographic stone, and his examination and description of the slate-quarries he had first discovered in the Western Ghâts, and his report to Lord Clare and the Governor-General of India on the geological structure of that portion of Western India which lies between the 15th and 19th degrees of north latitude, were all important scientific services; and on his return home the activity of his mind did not relax, and he spent his time in educating his own family, seeking to find some congenial employment that might keep his faculties in full exercise.

In 1843 he began to set up with his private funds a lithographic press, for the purpose of promoting the education of the natives of India, whom he loved to his dying hour, and wished to see enlightened. The productions of his press were all of a useful character; and the first thing he did was to prepare forms for the E.I.C. for the collection of revenues, the management of the marine engines of the navy, and a variety of other forms, which he furnished, by the highly scientific processes he adopted, at a very moderate charge. Among the various papers which Major Jervis proposed to the Indian Government is one which is of great importance, as it urged the adoption of properly lithographed post-office-orders in India. In writing to Lord Hardinge, March 24, 1845, Major Jervis says: "A Government post-office-order and letter of advice, in the opinion of General Morrison, formerly in the Supreme Council, several of the most eminent judicial authorities lately in India, and many of the members of the Court of Directors, would go further to suppress murders, crimes, and misrule consequent on the transmission of money by private hands than any other thing."

The few maps and papers printed by Major Jervis at his private press were equal to the best of the day, according to the testimony of many able geographers; and Mr. Greenough thus writes, "Your map of the Duskrooe Purgunnah is admirable both in design and execution: would that the whole of India were laid down on your model!" (December 6, 1844); Sir G. Rennie says, "I could not have conceived the perfection to which the lithographic art had arrived till I saw these specimens, although we have had much experience in our dealings with the trade for railway and other maps" (January 21, 1845); while with regard to the maps of

India in the vernacular languages, which Major Jervis was desirous of making for the missionary-schools, had funds permitted, Mr. Davis, the best Chinese scholar of all Europe, speaking of the Plan of Peking, was pleased to say that it was the *finest specimen* of Chinese writing he had ever seen, and he would compare it with the *native Chinese*. Nor was the encouragement of native female education a trifling object aimed at by Major Jervis, who felt how important the example of mothers must be in after life to the rising generation.

At the commencement of the Russian war, Colonel Jervis examined the materials forthcoming to enable the allies to gain a knowledge of that country, and early fixed upon the magnificent map of the Crimea which had been prepared by General Mukhin and the Russian staff. He obtained permission to trace it himself at a Continental library, and, having completed it and translated the names into English, brought it to England to lay it before the Duke of Newcastle, along with other rare documents not to be procured in England. After urging the subject long and frequently, and impressing upon the Government the absolute necessity of having *geographical* information for the troops, his Grace permitted him to furnish two or three copies of each of these documents, officially, to commence with. In *ten days*—less time than he could have sent to Vienna for another copy of the Austrian map of Turkey—he produced, entire in twenty-one sheets, two hundred copies at the service of the Government! The map of the Crimea was also ready before the army left Varna; and by it Lord Raglan mentions that he made his flank movement by MacKenzie's farm. Soon after, the Government sent copies of these maps to the general-officers; and in alluding to this subject, Colonel Jervis wrote thus to the Duke of Newcastle:—(1854.) “I believe it is not generally known that the present is the *first war in which the British forces have been supplied with the most needful help to success, correct and suitable land-maps*. To your Grace and Lord Raglan's acceptance of my services is ascribable, as well as to the exertions of the Hydrographer at the Admiralty, Admiral Sir F. Beaufort, and his coadjutor Capt. Washington, R.N., that the army has been furnished with the earliest and best information of the distant countries in which they are now engaged. This service as regards the army has been honourably recognized by the principal Staff-Officers, the Commander-in-Chief, and many distinguished personages in France and England; nor least by her most gracious Majesty the Queen, the Emperor of the French, and the Ministers of War and Marine.” In an unknown country, on a conflict so momentous, geographical information must be inestimably valuable.

Much of this important service was carried out at his own cost and by his own and his son's labour; and he pressed upon the Government in very emphatic terms the advantage which would be derived from the establishment of an office in connexion with the army, similar to that of the Hydrographical Office connected with the navy.

● After some months, Colonel Jervis procured from the French Government 1476 maps of the choicest kind, and offered these as a nucleus for the new office. Soon after, he was appointed, March 1855,

to be the Director of the Topographical and Statistical Depot of the War Department, with one assistant to attend to the details of working, &c., and, to act as his deputy in his absence, his son, Mr. W. P. Jervis, all other assistants being merely hired by the week. This was almost the last work of the Duke of Newcastle, and will doubtless be remembered as one of the greatest improvements in the organization of our army, for the first step taken by Colonel Jervis was to impress the Minister with the importance of attaching to his office a set of intelligent officers who should form a topographical corps, and accompany the troops in the Crimea, Asia Minor, and indeed in every campaign. The first corps sent out under Colonel Jervis, and equipped with instruments, &c., went to Erzerum, where they surveyed the whole sources of the Euphrates on a large scale, and the plain and town of Erzerum, sketching in the hills, &c.: this survey was afterwards employed in connexion with the frontier-survey from Ararat to the coast. Lord Panmure did not sanction a topographical corps for the troops at Sevastopol, though the Engineers of the Turkish Contingent were regularly supplied with instruments and materials from the Topographical Depot, and sent home some valuable maps. It may however be observed that the propriety of attaching a scientific corps to the Crimean army had been submitted to Lord Raglan by a different person, and that the project would have been carried out had not insurmountable difficulties appeared in the way. Lieut.-Colonel Jervis had the merit of originating the important establishment of a Topographical Office in the War Department, and he did much with limited means; we must not however condemn the higher authorities for not at once raising such an establishment to its utmost elevation, as no men in power can neglect the necessary economy of public money. It cannot be doubted that the Topographical Office will go on improving in excellence and importance, and that the remembrance of its first head will be long associated with it. The works of Lieut.-Colonel Jervis on geographical and other scientific subjects were very numerous; and I may mention especially, as proofs of his labour or ingenuity, his model of Sevastopol, which is in the War Department (it is 14 feet by 10, on a scale of ten inches to a mile, with true altitudes, and was coloured skilfully by the kindness of Mrs. Colonel Jervis), and a new system of projection for maps, called by him "cycloidal," and which has been employed in his official maps of the Caucasus (two sheets) and the S.W. of Asia, Circassia, the Caspian, &c.; of these, nine sheets are more or less completely engraved and issued.

Lieut.-Colonel Jervis is now gone; but we may fairly say that the East India Company has seldom possessed an officer of more energy and ability, that his services at home were very valuable, and that in every respect he was a most kind and estimable man, fulfilling all his duties, as a loyal subject, a faithful husband, and an affectionate father, in the most exemplary manner.

GEORGE WEARE BRACKENRIDGE, F.S.A., was born on the 4th of January, 1775, in Hanover County, Virginia, at that time still sub-

ject to the British crown. He was the eldest son of George Brackenridge of Winash, Brislington, who was a Scotchman by descent, though born at Bristol, where his family had recently settled, and of Sarah, youngest daughter of Francis Jerdone, Esq., of Louisa County, Virginia, and formerly of Jedburgh, N.B. The father of Mr. Brackenridge had settled in America as a planter and merchant; but, entertaining conscientious scruples on the principles and propriety of the American revolution, he returned to England, and placed his son at the school of Dr. Estlin, at Bristol, where he was initiated in the mysteries of commercial pursuits, and became ultimately the senior partner in a leading and long-established West India firm. As a man of business he was characterized by high principles of honour and integrity, and by habits of accuracy and punctuality. He exhibited at an early age a taste for science and literature, and in spite of the demands of commerce upon his time, rendered more absorbing by the distractions of the revolutionary war, he found leisure for inquiries into mediæval antiquity and more than one branch of natural history. He formed a good collection of the *Coleoptera*; and his cabinet of organic remains, which in the early days of geological science was of much repute, is still of value for its specimens of fossils connected with the strata of the West of England. He was very accurate in his examination of fossils, and brought under the notice of Mr. Sowerby a specimen of Ammonite, remarkable for the striking and peculiar form of the lip, which was found at Dundry, near Bristol. Before arriving at his fiftieth year, Mr. Brackenridge abandoned his commercial pursuits, and purchased the residence of Brislington. He had before, like many of our leading men of science, found it possible to exercise the faculties of his mind during many a leisure moment on objects of more stirring interest than the dry details of business; but he now gave himself up to the full gratification of his refined tastes, collecting much more largely than he had done before, fitting up his library in the Tudor style, and enriching it with richly-cut furniture, and with fine specimens of stained glass. As an antiquary, he devoted much attention to the investigation of the architectural features of Bristol, that picturesque old city, where he had passed so much of his early life, and to the preservation of many of its ancient relics.

He assisted most liberally in procuring the best illustrations for 'Collinson's History of Somersetshire,' which work must therefore be looked upon as bearing testimony to his love of topographical research.

Having for the last twenty years of his life spent the summer and autumn at Clevedon on the Bristol Channel, he liberally promoted the building of a new church on Clevedon Hill, contributing the greater portion of the building-fund, and adding a permanent endowment: his son was appointed its first minister in 1839, when the church was consecrated. Though, from his retired and domestic habits, he was not generally known in his neighbourhood, he was valued by those who did know him for the kindness of his disposition, his great powers of conversation, and the many sterling qualities of his character. He married, Nov. 11, 1800, Mary, youngest daughter of Robert Burt, Esq., of Bristol, and of Tracy Park,

near Bath, who died March 20, 1855. He was not long left behind her, as he died February 11, 1856, at his house at Brislington, near Bristol, aged 81.

CHARLES WILLIAM WENTWORTH FITZWILLIAM, fifth Earl FITZWILLIAM, K.G., was best known to the world as an enlightened liberal politician, but his claim on our respect is founded upon his desire to promote the intellectual advancement of his fellow men, as manifested by the fact that since the year 1833 he filled the office of President of the Yorkshire Philosophical Society. He has been succeeded by the Earl of Carlisle, but the services of twenty-eight years' presidency are not likely to be forgotten by the members of the Yorkshire Philosophical Society.

As a soldier myself, I cannot pass by the name of Colonel W. G. ELIOT in silence, though I have been unable to obtain any specific notice of his life. The officers of our military and of our naval profession should be encouraged to enter upon a study which is so capable of being made valuable in practice; and the very fact of joining our Society proves that regard for science which it is our object to inculcate and to cherish.

I have now to notice the distinguished foreign members whom it has been our misfortune to lose during the past year, and I shall begin with M. ANDRÉ HUBERT DUMONT, who was so well known to many of our leading members, and whose career, though short, was productive of great results. He was born in 1809: and such was his earnest pursuit of his favourite science, that at the age of twenty (in 1829), he produced his first geological essay on the "Geological Constitution of the Province of Liege," and addressed it to the Royal Academy of Belgium, by which body it was crowned with honour. Ten years afterwards the merits of this work obtained for M. Dumont the award of the Wollaston Medal from our Society. In 1834 (April 5) he was chosen a corresponding member of the Belgian Academy, and in 1836 (Dec. 15) he was admitted a regular member. About the same time, at the recommendation of the Dean of the Academy, and of the late M. Cauchy, also a member of the Academy, M. Dumont was named, by the Government, Professor of Mineralogy and Geology to the University of Liege, and was requested to undertake the difficult and important task of drawing up a geological map of Belgium; and it is much to be feared that, honourable as that work must be considered to his native country and to himself, the labour and anxiety connected with its preparation were fatal to his health.

In 1852 his Memoir on the Rhenish and Ardennes Formations, including the Ardennes, Brabant, Condroz and the Rhine, shared with De Koninck and Van Beneden the first great quinquennial prize in the natural sciences decreed by a jury selected from the Academy. In January 1855 the Academy selected him as its director for the year 1856, and he had only completed his year of office two months when he was snatched away by death: and it may be considered a touching

incident, that the only survivor of those members who assisted at the foundation of the Academy, M. D'Omalius d'Halloy, came to Belgium to bid adieu to Dumont, whose early progress he had encouraged, whom he loved as a son, and by whom he was revered as a parent. For twenty years his life was devoted to the preparation of the geological map, during which time he shrank from no labour either of body or mind, exploring every spot in Belgium, and not allowing a single geological fact of importance to escape his attention, so that his inquiries extended from the primary to the tertiary formations inclusive. The merit of the map cannot be disputed, even though doubts may be entertained as to the nomenclature made use of; and we may adopt the following words of one of his eulogists, without reserve: "Though he was, perhaps from a natural disdain for ordinary means of success, too careless about popularizing his ideas beyond the class he taught, his maps will retain their value, even though it may be necessary to change his nomenclature; and they are so manifestly stamped with the character of exactness and reality, that it may be expected that the divisions which he has adopted will be hereafter taken as general types of formations: indeed they have already been adopted in Germany for many formations, so that they have already obtained a place in geological science." The failure of his health forced M. Dumont to travel; and he discovered on the shores of the Bosphorus, and on the mountains of Spain, formations equivalent to those he had recognized on the plains of the Ardennes and of Condroz; and it was then that he conceived the idea of forming a geological map of Europe, a map which has appeared, and must be looked upon as one of the first serious attempts to establish on a large scale the geological correlation of the various countries of Europe.

Like our late friend Mr. D. Sharpe, to whom he was well known, he was snatched away in the very prime of life, and at a moment when still greater advances in geological science might have been reasonably expected from him. The University and the Government of his country had however done much in that brief time to testify their estimation of him. Many of his academical honours have been already noticed; but it may be mentioned that he was a Commander of the Order of Leopold, a Knight of the Order of Conception of Villa-Vieosa of Portugal, and of the Polar Star of Sweden, whilst he was a member and one of the founders of the Royal Society of Sciences of Liege, Member of the Society of Sciences, Arts and Belles Lettres of Hainault, Honorary Member of the Central Society of Agriculture of Belgium, of the Association of Engineers, formed on the model of the School of Mines, and of the Society of Emulation, Member of the Academies of Naples and Turin, formerly President of the Geological Society of France, Member of the Imperial Society of St. Petersburg, of the Society of Naturalists of Moscow, Corresponding Member of the Society of Physical, Chemical, and Agricultural Sciences of France, and since 1841 a Foreign Member of our Society, the loss of whom will be deeply regretted by many of our members, and by none more than Mr. Austen and Mr. Prestwich, both of whom were intimately acquainted with him personally and knew well his worth.

The preceding observations are sufficient to prove how fully M.

Dumont had earned the high character for unwearied zeal and energy in geological research, ascribed to him not merely by his own countrymen, but by the geologists of all Europe: some further remarks on his writings are, however, necessary to give a clear idea of his great and varied talents, as well as of that independence of mind which led him perhaps sometimes to an excessive dread of being shackled by systems. The Memoir on the Geological Constitution of the Province of Liege was his first great work, and gained the prize offered by the Academy of Brussels for the essay which should best fulfil the following conditions: "describe the Geology of the Province of Liege; point out the mineral species and accidental fossils which are there found, the localities where they occur, and the synonyms of all substances already known and which have been before described." There were two other competitors for this prize; and the epigraphs attached to the papers of Dumont and of his next ablest opponent, who gained a silver medal, are as follows: that of the second competitor was a passage from Baillet to this effect,—“few systems and many facts, ought to be the motto of a Naturalist,” a sentiment which well defines the views of Dumont himself, whilst his own epigraph; “the relative age of the primordial rocks cannot be determined with certainty from their inclination,” may be taken as the expression of the results of his labours.

M. Dumont adopts the nomenclature of D'Omalus d'Hallo for "Terrains" or Formations, and that of Alexandre Brongniart for Rocks. The primordial formations of the province of Liege he describes as occurring in basins, the stratification as conformable, and the rocks as divisible into three groups, which, in conformity with the views of D'Omalus, he designates the Schist- or Slate-group, the Anthraciferous group, and the Coal-group; the coal-group resting on the anthraciferous group, and that upon the slate-group.

Describing his rocks from below upwards, he enumerates in the slate-group: 1. Diallage-slate, consisting of a paste of talc with lamellar diallage disseminated; 2. Red Slate, consisting also of a talcose base, with red grains of (?) peroxide of iron; this and the preceding belong to the "Steaschiste" of Brongniart; 3. Common Clay-slate; 4. Quartz- and talc-slate; 5. Granular Quartz; 6. Talcose Conglomerate and Puddingstone; 7. Freestone or Diorite of Brongniart.

These rocks might be considered as forming parts of one great whole, the varieties being consequent on the accidental presence of certain mineral elements in different parts of the series at the time when crystallization was induced in the mass by metamorphic action; but M. Dumont divides them into two systems: the Inferior comprising the Diallage-slate, the Granular Red Slate, the Talcose Puddingstone, and a little Clay-slate; whilst the upper system principally consists of common Clay-slate and of Granular Quartz, including in some parts Talc-quartz-slate and Greenstone: but this arrangement, if invariable, would be quite consistent with the theory of a simultaneous metamorphic change through the whole mass.

The several rocks which have been named as constituting the Slate-formation are not irregularly distributed, but are arranged in definite order. The whole formation in the province of Liege is divided into

three distinct portions by the Anthracitiferous formation: on the South-east it occupies the whole region of the Ardennes, and is there covered only by its own debris, except in one locality, where a small band of the "Penean" (the Permian of our nomenclature) comes to the surface; at the North-east it is almost entirely covered by secondary strata, whilst in the centre of the great Anthracite-basin it occurs in discontinuous bands parallel to the lateral edges, which have thus been lifted up like islands in the centre of the great depression. Had this elevation been carried sufficiently far, the Anthracitiferous formation would have been divided into two parts; but it has stopped short of a complete separation, the lower quartz-slate of the Anthracitiferous formation covering it in many places, though the limestone immediately above the quartz-slate is completely divided into two principal basins by the quartz-slate. In the Ardennes alone is the lower system of the Slate-formation found, and it there forms a single band, whilst the upper system occurs as two bands, one to the north and the other to the south of the lower system. It is unnecessary here to follow M. Dumont in his very careful and able examination of the mineral character and products of these rocks; but it may be said that the symmetrical arrangement of the rocks forming the lower system, in the following order from below upwards—Diallage-slate, Red Slate, Common Slate, Talcose Puddingstone—on each side of an antilinal axis, proves that the lower system here forms a saddle-shaped elevation, just as the upper system appears to do in the centre of the basin, with this difference, however, that it is not covered, as the upper system partially is, by the next series in regular order of superposition. Passing over the local descriptions of the Slate-formations, the Anthracitiferous formation is next in order, and is divided by M. Dumont into four systems, namely: 1st, Slate, Sandstone, and Conglomerate, called the Lower Quartz-slate; 2nd, Limestone and Dolomite, called the Lower Limestone; 3rd, Slate and Sandstone, called the Upper Quartz-slate; 4th, Limestone and Dolomite, called the Upper Limestone: and in both the limestone-divisions the Dolomite occurs, though not always present, between two beds of common limestone. M. Dumont, in his remarks upon the order of superposition of these rocks, states that the lower quartz-slate-system graduates, at its junction with the slate-system of the Ardennes, so imperceptibly into the slates, that it is scarcely possible to mark distinctly the line of separation, and he refers this system to our Old Red Sandstone; but he does not in this Essay effect a correlation of the three remaining systems of the Anthracitiferous formation with English formations, nor do I think that the list of fossils he gives would alone have enabled a geologist to decide on the true position of the Anthracitiferous and Coal formations of Liege; as, for example, in the fossils of the Lower Quartz-schist appear the names *Productus hemisphaericus*, *P. comoides*, *P. concinnus*, and, in the Upper Limestone System thereof, *Calymene Tristani*, *C. macrophthalma*, whilst in like manner *Spirifer attenuatus* is recorded as occurring in the Upper Quartz-schist below the Coal-field, and in the Penean or Permian formation above it I do not mention these palæontological obscurities with an intention to detract from the great

merits of M. Dumont's Essay, but simply to show how impossible it is to determine the relative ages of the strata of the earth without an appeal to the fossils, or, in other words, to the Natural History, of each successive epoch. M. Dumont detailed with the utmost ability the mineral structure and the physical peculiarities of the province of Liege, and his work became a natural basis for the future researches of himself and others; but a district so much undulated by disturbance was not to be satisfactorily unraveled by such a system of investigation alone. The identification, however, of the Lower Quartz-schist of the Anthraciferous formation with the Old Red Sandstone, and the determination of two successive limestones, the lower and the upper, were important steps towards the final establishment of the Devonian as a true formation.

In his subsequent memoirs on the rocks of the Ardennes and of the Rhine, M. Dumont observes that in his preceding work he had proved the accuracy of M. D'Omalius d'Halloy in dividing the primary strata of the North of France into the Slate, Anthraciferous, and Coal formations; and he then adds that subsequently Sir R. Murchison had proposed for the same formations the names of Silurian, Devonian, and Carboniferous,—denominations which, having been adopted by many French geologists, had replaced those of D'Halloy. M. Dumont also admits that the undulations and disturbances of the four systems into which he had divided the Anthraciferous formation produce such indefinite alternations of the calcareous, schistose, and quartzose divisions, as to render their study very difficult, though he states that by *purely geometrical* considerations he succeeded in demonstrating the existence of two calcareous deposits within the Anthraciferous formation, and adds that Murchison had arrived at the same result in England, having allocated the Lower limestone to the Devonian, and the Upper to the Carboniferous formation. Without doubt the labours of M. Dumont were in this respect most valuable, as affording a proof of the just claim of the Old Red Sandstone to be considered part of a true formation, and his observations correct; but his subsequent remarks are not equally well-founded, when he speaks of the difficulties which those first-rate geologists, Sedgwick and Murchison, experienced in determining the precise boundary between the Cambrian and Silurian formations, as proofs of the insufficiency of a study of organic remains to settle such questions. This idea he endeavours to strengthen by pointing out the differences of opinion which have existed in respect to the quartz-schist of the Ardennes and of the Rhine, which Sedgwick and Murchison had placed in the Silurian, whilst M. C. F. Roemer had considered, from the study of organic remains, that the quartz-schist of the Rhine belonged to the Devonian, and MM. D'Archiac and De Verneuil, from their examination of the ancient fossils of the Rhenish Provinces, had placed the grey slates of Nieder-Prüm in the Silurian, though, in M. Dumont's opinion, above the red grits of the quartz-schist-system of the Anthraciferous formation; and he then concludes that Palæontology had proved insufficient, and proceeds to establish the divisions of the ancient Schist-formations by his own *geometrical method*.

He divides his memoir into two parts, the first treating of the Ardennes, and the second of the Rhenish strata, and adheres to the same principles of subdivision which characterized his first work; adopting for the Ardennes the following systems from below upwards: 1st, the Devillian, 2nd, the Revinian, and 3rd, the Salmian, the names being all derived from special localities; and for the Rhenish, 1st, the Gedinnian, 2nd, Coblentian, 3rd, the Ahrian, also local names. The Ardennes and Rhenish formations are all composed of quartz-slates, quartz rocks, grits, &c., and underlie the Anthraciferous formation, which M. Dumont subsequently subdivided into three systems, the Eifelian, the Condrusian, and the Coal, so that the Devonian was here confounded with the Carboniferous in one formation characterized merely by its carbon constituent. M. Dumont exhibited the same mineralogical skill in the examination of all these rocks, and the same care in describing his different systems, which, as they closely resemble each other, must have caused him great trouble. The various contortions of rocks he notices are also sufficient to indicate the complexity of the district; but he manifestly considers the question of fossils as one of secondary importance. M. Dumont in 1838 referred to his former determination of the correlation of the Eifel formation with the Anthraciferous formation of Belgium, and stated that he had subsequently visited Wales in company with MM. D'Omalus d'Halloy and De Verneuil, in order to determine in a similar manner the correlation of the English and Belgian strata; and he comes to the conclusion that the divisions established by Sedgwick and Murchison, as Cambrian and Silurian, correspond with the Slate and Anthraciferous formations of D'Halloy: on this supposition he considers the Slate-formation of Belgium as the representative of the Cambrian formation, and the Anthraciferous formation as including the whole of the Silurian system and the Carboniferous formation in the following order:—

| | | | | | |
|---------------------------|--|---|---|------------------|--|
| Anthraciferous Formation. | Upper Lime-stone. | <div> <div>Limestone</div> <div>Dolomite</div> <div>Limestone.....</div> </div> | Carboniferous Limestone. | Silurian System. | |
| | (Old Red, supposed to be absent in Belgium.) | | | | |
| | Upper Quartz Slate. | <div> <div>Grit.....</div> <div>Limestone</div> <div>Slate with subordinate Limestone</div> </div> | <div> <div>Upper Ludlow.</div> <div>Aymestry Limit.</div> <div>Lower Ludlow.</div> </div> | | |
| | Lower Limestone. | <div> <div>Limestone</div> <div>Dolomite</div> <div>Limestone</div> </div> | Wenlock Limestone. | | |
| | Lower Quartz Slate. | <div> <div>Grey Fossiliferous Schist</div> <div>Schist and red Grit, conglomerate Grit, Quartzite, Schist ...</div> </div> | <div> <div>Wenlock Strata.</div> <div>Caradoc and Llandeilo.</div> </div> | | |
| | Slate Formation. | <div> <div>Upper.....</div> <div>Middle</div> <div>Lower</div> </div> | Cambrian System. | | |

M. Dumont adds that it is doubtful whether the Old Red exists at all in Belgium, so that he abandons his former conclusions; and as he adds, that, though the divisions established by Murchison on fossil evidence in England were good for that country, they would be found palæontologically different in Belgium and other countries, it is quite evident that he had not then succeeded in establishing, by his system of examination, the true age of the Belgian rocks, and that the ultimate application of the English system was necessary to reduce this important geological district into order. It is indeed with regret that we observe so able a man persevering in ignoring the well-known names of Silurian and Devonian and adhering to that of Anthraciferous, which must perplex rather than inform the geologist; but, making a fair allowance for his high respect for his old master in the science of geology, D'Hallo, which manifestly interfered with his examination of the older rocks, it is evident that however able in many respects his classification, more especially that of 1852, was, it is gratifying to turn to his researches on the Tertiary strata. Here his judgment was less shackled; and I freely quote the following practical observations with which that profound Tertiary geologist, Mr. Prestwich, has favoured me.

M. Dumont now directed his attention to the Tertiary strata, which until that time were in a most perplexing state of confusion. Without any clearly-established order of superposition, with fossils belonging to upper beds placed in the lowest beds, and with no accurate sections, it was impossible for foreign geologists to establish their correlation with the Tertiary strata of the adjacent countries. One equivalent deposit only had been distinctly recognized, viz. the relation of the Brussels Sands to the Calcaire Grossier of Paris; but all previous descriptions of the beds above and below that group were full of inaccuracies and very incomplete. This in part was owing to the want of natural and artificial sections, arising from the flatness of the country and the scarcity of building-stones in the Tertiary series. In 1839, in a report to the Royal Academy of Brussels, M. Dumont gave his first sketch of the classification of the Belgian Tertiaries, dividing them into a series of "systems" distinguished by local names. This plan he from time to time enlarged and improved, still retaining the original groundwork, and finally establishing ten principal groups, of which the following is a list:—

- | | | |
|-----------------------|---|-----------|
| 1. Scaldisian System. | } | Pliocene. |
| 2. Diestian System. | | |
| 3. Bolderian System. | | |
| 4. Rupelian System. | } | Miocene. |
| 5. Tongrian System. | | |
| 6. Laeckenian System. | } | Eocene. |
| 7. Bruxellian System. | | |
| 8. Paniselian System. | | |
| 9. Ypresian System. | | |
| 10. Landenian System. | | |

To establish the correlation of these groups, M. Dumont visited

the Tertiary districts of France and England, and published a table of equivalent strata, showing great ability and sagacity; but unfortunately the data on which the synchronisms are based, both with respect to organic remains and physical structure, are not given. The main points on which M. Dumont throughout insists are the breaks in the sequence, corresponding with certain movements of elevation. The fuller descriptions and lists of fossils were reserved for a larger work, of which unfortunately his early death has deprived science. A table embodying his most recent views was published in the Journal of our Society for 1852.

To the great and extensive deposit of loamy drift which covers so much of Belgium, he applied the term of "*Limon Hesbayen*," being a portion of his "*Système diluvien*," which again was a section of the "*Terrains Quaternaires*." The deposits arising from hot springs, evolutions of vapour, and gases, he proposed to designate as of "*Geyserian*" origin, in contradistinction to rocks of igneous and sedimentary origin.

It will be observed from the preceding remarks, that, whilst recognizing the great value of a purely mineralogical examination of a country, both as regards a correct determination of the true causes of metamorphism and with a view to trace out the physical forces which have contributed towards the present constitution and distribution of mineral strata, I have endeavoured to show that no perfect knowledge of the successive epochs of the earth's history can be acquired without the study of its fossils, or in other words, of its natural history. Neither of these modes of inquiry should be neglected, as it is quite evident that any one taken alone can give but an imperfect notion of the whole subject. M. Dumont directed his efforts, and they were great and most skilfully conducted, to the mineral mode of investigation; but there is little doubt that he would, had his life been spared, have ere long given more attention to the palæontological mode of inquiry, as being the only one which can make the works of the geologist a philosophical history, and not a mere dry account of isolated facts.

I do not consider it necessary to dwell on M. Dumont's mineralogical essays, or on his description of Louisiana; but the paper which he read to the Academy of Brussels on the 22nd November 1834 deserves especial notice, as it refers to that much-vexed question, the origin of the volcanic craters of the Eifel. These he enumerates as craters of elevation, craters of eruption, and lake-craters; and he observes that the conical mountains, known in the Eifel as volcanic, have generally no appearance of a crater. They have a circular base, a summit more or less pointed, and tolerably uniform slopes: they are, for the most part, formed on one side by scoriaceous matter, and on the other by inclined beds of compact lava or tephrite, similar to that which extends into the plains in a more or less horizontal sheet, whilst at the foot of the inclined beds is often found a *trainée* of large blocks of the same description. These conical mountains, M. Dumont calls "*cones of elevation*," and he explains the facts described in the following manner. The com-

pact lavas and the tephrites were already formed, had been spread in uniform sheets over the surface, and cooled before the scoriaceous matter had been forced upwards and exposed to view. The pressure from below upwards, exerted by this matter on the upper sheet of lava, first fissured it in a star-like form, over an extent of ground proportional to the force, the radii of the sector-like spaces proceeding from the point of application of the force; the scoriaceous matter then forced its way through by lifting up that portion of the sectors which offered the least resistance, escaping by the opening formed, and completing the cone, of which the elevated sector formed only a part. The blocks scattered over the ground at the foot of the sector were detached and projected at the time of the elevation. The mode of formation of elevation-craters, M. Dumont derives from the preceding explanation; when, for example, the sum of the areas of sectors raised constituted but a small portion of the circumference, the result was a conical mountain only; but when the larger portion or the whole of the sectors had been uplifted, the scoriaceous matter could no longer fill up the cavity formed, and a true crater of elevation was then the result. As an example, M. Dumont quotes the crater north of Mayen, near Ettringen, where the beds of tephrite which are horizontal in the quarries of Mayen are observed to be tilted up, whilst the scoriaceous lavas are seen to underlie them and to fill up several vertical fissures which correspond to the radii of the sectors. M. Dumont adds that there can be no doubt from a consideration of these facts, as to the mode of formation of this kind of crater. Of craters properly called craters of eruption, M. Dumont states that the only well-characterized one he has observed is that near Gerolstein, which is situated on the summit of a calcareous hill, and has a well-marked excavation, containing scoriaceous lavas. It would appear, then, according to this explanation, that when the flexibility of the strata is sufficient to yield to the pressure without being broken off, either a cone or a crater of elevation will be formed; but when inflexible, the mass of the rock is torn away, and a true crater formed, round which the scoriaceous matter would be then arranged. The lake-craters, though apparently proceeding in the first instance from the uplifting and rupture of a portion of the rocky crust of the earth, do not generally exhibit any appearance of true volcanic rocks, the place of the scoriaceous lavas being here supplied by agglomerates, the paste of which is dried mud, and the imbedded nodules fragments of the fissured schists and grits of which the borders of the crater consist. The volcanic bombs found in connexion with these craters, M. Dumont considered as having been projected through the mass of mud at the time of the eruption, the granular structure of the bombs being analogous to that which a vitreous substance strongly heated, and then suddenly cooled, would assume. This is an interesting view of a very obscure subject, and, though in a certain degree speculative, may be fairly considered as one of the most systematic explanations of the formation of craters which has, up to the present time, been attempted*.

* Whilst this address has been passing through the press, the subject has been

I trust what I have said will be deemed sufficient as affording an ample proof of the great and varied abilities of our deceased member, whose zeal and energy in the prosecution of his favourite science was such that Mr. Prestwich has estimated that he *walked* no less than 15000 miles whilst examining the geology of Belgium; for it was his rule to form his judgment entirely upon his own observations. He is gone; but his great labours will never be forgotten, and his excellent social qualities will be long and affectionately remembered.

M. P.A. DUFRENÓY was born on the 5th September, 1792, and was therefore sixty-five years of age at the time of his lamented death. His mother, Madame Dufrenoy, was a lady of great literary acquirements and a poetess of considerable eminence, having founded her style upon classic models, the native language of Virgil and Horace being familiar to her. Amongst other works she wrote a poem on the last moments of Bayard; and its beauty merited and obtained the approbation of the French Academy, by which distinguished body it was crowned. This excellent woman, at a time when she had long suffered from illness, wrote the following touching lines, commemorative at once of her feelings of affection, and of her confidence in the future fame of her beloved son:—

“Oui, mon fils, oui, ma noble idole,
De mon été qui fuit, ton printemps me console.
Eh ! comment du passé garder le souvenir,
Quand les mâles vertus de ton adolescence,
Et tes savants travaux, suivis avec constance,
Répondent de ton avenir !”

The recollection of this highly-gifted mother was always fondly cherished by her son, who was never weary of dwelling upon her high qualities as a wife and mother. Nor was he less fortunate in his marriage, as his wife, a daughter of M. Jay, was a fitting companion for such a man, and, after bestowing the necessary maternal cares on her three sons, of whom she was justly proud, was ever ready to assist her husband in his labours by correcting proofs, by translating works written in foreign languages, or by making drawings as illustrations of his own works. This amiable woman survives her husband, and must be an object of admiration and of respect to all men of science.

In 1803 M. Dufrenoy was a schoolfellow of M. Valenciennes, the celebrated ichthyologist, at the Lyceum of Rouen, where both the young friends acquired a taste for the study of the natural sciences; and, although they cultivated different branches, were often in communication with each other on scientific subjects, and finally became colleagues at the Museum of Natural History, and fellow members of the Academy of Sciences. Having completed his literary and again discussed by one of our greatest and most philosophical geologists, Sir Charles Lyell, who considers the elevation-theory as untenable. This is not the place to enter into a discussion of his facts or arguments; but I may venture to say, that the force which was sufficient to raise the semi-liquid lava to a great height, and there to erupt it, must have been also sufficient to fissure and uplift the consolidated crust of the earth.—J. E. P.

scientific studies at the Imperial Lyceum, he entered the Ecole Polytechnique in 1811, and having attained a very high place in that institution, so well known for the high standard of education it maintains, he became one of the Corps des Mines in 1813. Soon after the establishment of a School of Mines, M. Dufrénoy was enlisted in its management; and it is justly said that its prosperity has been mainly due to the prudence and ability with which he has managed its concerns. He quickly associated himself with M. Elie de Beaumont, who bears the warmest testimony to his worth, both as a Professor and a Director:—"He was always," M. de Beaumont observes, "clear and solid, and knew how to fix attention on the most dry subjects, or to render the most difficult easy of apprehension: perhaps, indeed, crystallography had never an interpreter more successful or more elegant in his mode of explanation. As a Director he will ever be considered a model. With all his modesty, gentleness, constant desire to be strictly just, and indefatigable efforts to be useful, he always exercised his power with such judgment, that during 40 years passed at the School of Mines, the most perfect order was preserved. He never spoke harshly, and yet no one would have thought of disobeying him. Every one would have been grieved at the very thought of annoying him, and he constantly lived as it were amongst a body of friends." In 1823 he commenced, in conjunction with M. Elie de Beaumont, the important work of a Geological Map of France, and that at a time when the geology of France had been the subject of no detailed works, so that almost everything required to be founded on new observations. In less than twenty years this great work was finished, and is now considered by geologists of every country as an example worthy of imitation in all similar works, whilst it is a frequent work of reference to the practical agriculturist and other industrial agents of France.

It is to be observed that before commencing this great work, the two young friends visited England, which had become classic ground for geologists, in order to study there the Secondary formations, and it cannot be doubted that, whilst obtaining information on the one hand, they must have been instrumental in communicating it on the other. The publication of the "*Metallurgical Voyage to England*" was indeed a most valuable addition to our knowledge, as at that time there was no work extant in the English language which gave so complete an account of our mineral riches and of our industrial establishments for working them. He afterwards visited England on a special mission to examine the improvements which had been introduced into our foundries, and at the Universal Exposition of Industry in 1851 he was the delegate from France, when he was elected Vice-President and Reporter of a Commission composed of representatives of all nations. As a geologist, his labours were various and important, either conjointly with Elie de Beaumont, or independently by himself; it is said, indeed, that his works had a powerful influence in rendering geology popular in France, and that he deserves to be ranked amongst the first founders of the Geological Society of that country.

His researches in Auvergne, where he demonstrated the alternate

disposition of tertiary lacustrine and volcanic strata, and those on the volcanic strata of the neighbourhood of Naples, where he distinguished between the trachytes and pumice of the Phlegrean fields and the ancient lavas of Somma, as also between those ancient lavas and the recent lavas of Vesuvius, are proofs of great sagacity and judgment. It is to be observed, however, that he shared with M. Elie de Beaumont and M. Dumont in the belief of the theory of uplifted craters, and endeavoured to explain the mathematical laws of those forces which have produced the elevation of volcanic cones,—a task for which his mathematical education at the Ecole Polytechnique had eminently qualified him: indeed such an education seems indispensable for all those who intend to deal with the phenomena of physical geology. His work, again, on the age and composition of the formations of the West of France is one of much ability, his principal object having been to determine the geological position of the principal iron-mines and of the rocks generally of the Eastern Pyrenees.

His work on Mineralogy is very extensive, and is one of great merit: it explains not only the physical and chemical properties of minerals, but also their geological relations; and a very good judge has particularly extolled his critical acumen and his fidelity, remarking that “it is much more common in these times, to find mineralogists ready, on very slight grounds, to establish new and ill-defined species, than disposed to efface from the nomenclature substances which have no right to figure there. It is, in fact, easy to assume the merit of having given a name to a substance without having taken the trouble to study it sufficiently for an accurate definition; but it is a long, difficult, and ungrateful task to demonstrate the errors of others.” How true is this remark, and how applicable to the examination and determination of organic fossils!

So highly were the talents of M. Dufrénoy appreciated, that he was consulted on many difficult subjects extraneous to his ordinary duties, such as the purification of the Sologne and the management of the mineral waters of Vichy and Plombières; and it may be asserted that he was during his whole life the enthusiastic friend of science, and the successful promoter of every useful application of scientific knowledge.

M. ALCEDE D'ORBIGNY, Professor of Palæontology at the Museum of Natural History in the Jardin des Plantes, was remarkable for the vast magnitude, as well as for the interesting character of his palæontological works, intended as they were to embrace the whole field of geology in France, and, of course, comparatively to notice the relations of the ancient inhabitants of all portions of the earth whilst describing those of his native country. M. D'Orbigny was born at Couëzon (Loire Inférieure), and has been in succession Travelling Naturalist for the Museum of Natural History, Secretary of the Natural History Society, Member of the Central Commission of the Geographical Society, Assistant of M. Cordier in the Geological Course, and latterly placed in the chair of Palæontology which had

been created expressly for him. He was a Knight of the Legion of Honour.

M. D'Orbigny commenced in 1826 his travels for the Museum, under the auspices of the government. As a student at Rochelle, M. D'Orbigny passed his earlier years on the sea-shore, and employed much of his time in examining the natural productions thrown ashore by the waves. Before he had attained the age of twenty-two, he presented to the Academy a work which was attended with great success, as the committee appointed to examine it reported that, from the great number of new species he had made known, he deserved to be placed in the first rank of original observers. In 1826 he proceeded, as Travelling Naturalist for the Museum, on a voyage to South America, where he explored, with equal perseverance, courage, knowledge, and success, Brazil, Buenos Ayres, the frontiers of Patagonia, and the Republics of Chile and Bolivia, from the shore of the Pacific Ocean to the centre of the continent: he afterwards went through the Republic of Peru, and, when he returned to France, had visited all that portion of the earth from the 11th to the 12th degree of latitude, and from the Pacific to the Atlantic Ocean.

As the product of this voyage, M. D'Orbigny brought home most extensive collections and manuscripts, numerous drawings of objects of natural history, and everything necessary to illustrate the geography, the languages, the ethnology, and archæology of this part of America: historical manuscripts, thirty-six vocabularies of the American language, a collection of animals containing 7000 species, of which many were new, and one of about 2300 species of plants, as well as much information respecting the geology of the countries he visited, were amongst the results of his labours, and were embodied in the great work entitled, "*Voyage dans l'Amérique du Sud*," published under the sanction of the Minister of Public Instruction. He also superintended the publication of another work, "*Voyage pittoresque dans les deux Amériques*;" and his labours were appreciated by the Geographical Society of France, which awarded him its annual prize in 1836. As an active, intrepid, and persevering traveller, he had thus made his way over an immense extent of country, from Brazil and Peru to Patagonia, in eight successive years, sometimes navigating previously unknown rivers, sometimes penetrating virgin forests, resting on the loftiest plateaux of the Andes, or in the plains of Patagonia, frequently finding himself amongst contending tribes, and being obliged to take part in their conflicts.

M. Alcide D'Orbigny, who had thus studied nature under all its varied forms, now devoted himself to a task not less deserving of the admiration of posterity, as he thenceforth consecrated his life to the study of Palæontology, a science which had only sprung into existence in the nineteenth century, and which has already enabled the geologist to study the ancient natural history of the several epochs of the earth's history, and to determine by that clue the true relative age of the mineral deposits with which the fossil relics of

animals and plants, long since removed from observation as existing genera and species, are associated. It has been justly said that what he succeeded in accomplishing, in this new branch of science, was so vast as to be almost beyond the intelligence, and, I may add, the physical powers of any one man; and, as a proof, I will at present mention his Foraminifera of Cuba, of the Canaries, of Meudon near Paris, and of Vienna; his studies on the Crinoids, his "Prodrôme de Paléontologie," his "Course of Stratigraphic Geology," and especially his "Palæontology of France," which has extended to fourteen volumes, and contains 1400 plates of French fossils.

M. D'Orbigny was removed by death only four years after he had been chosen Professor at the Jardin des Plantes, and before he had had time to complete his great palæontological works, though it is believed that he has laid the foundation of a palæontological collection worthy of France. I have on a former occasion spoken of the nomenclature introduced by him into geology, which, although founded in great measure upon that previously adopted in England, deserves, from its simplicity, and in many respects its euphony, the ready reception which it has obtained on the Continent. In respect to his great work on the Palæontology of France, I am aware that many English palæontologists consider that he has been sometimes too hasty in the creation of new species; but this error, I fear, is common to a large portion of palæontologists, and will not be entirely remedied until naturalists have made their comparisons, not with drawings, but with actual specimens. Making, however, every deduction on that account, the works of M. D'Orbigny must ever stand forth as a memorial of the most persevering industry and of a high order of intellect, in confirmation of which opinion I will briefly but more particularly notice some of his numerous works.

In doing so I shall principally confine myself to the notice of such works and opinions of D'Orbigny as affect materially either the philosophy or the practice of geological science. Such papers as his Monograph of the new genus of Gastropods to which he gave the name *Scissurella*, or his description of two species of the genus *Pteroceras*, found in the jurassic limestone of La Charente Inférieure, or his essay on the beaks of fossil Cephalopoda, in which he divides the Rhyncholites into two divisions, belonging to different genera, one being the beaks of *Nautili*, and not of *Sepie*, as had been before supposed,—an idea supported by the anatomical description, by Professor Owen, of the *Nautilus Pompilius*,—or his note on the genus *Cuprina*, his tabular view of the class Cephalopoda, his memoir upon a second living species of the family of Crinoids, to which he gave the generic name *Holopus*, and many other of his papers, are sufficient proofs of his great knowledge of, and accurate judgment upon, almost all branches of natural history; but others speak the language of a philosopher on such subjects.

Every one will doubtless remember the different opinions which were once entertained on the true position, amongst organized beings, of the Foraminifera, some naturalists having, from the resemblance of form, allotted them to the Cephalopoda: after a careful examination

of the animal portion, as well as of the shelly covering of these minute, often microscopical, bodies, he disproved the earlier notion of their alliance to the Cephalopods, which he had himself at first adopted, and proposed a general classification of the Foraminifera, founded upon the form of their shells, placing them amongst the Radiata, close to the Polypes. In this great and important inquiry he described and figured 118 new species from the Island of Cuba and from the Antilles, and afterwards 43 species from the Canaries, of which 33 were peculiar to those islands. Nor was it to living Foraminifera that he confined his attention, as he described and figured 54 species from the white chalk of the Paris basin, all, with the exception of three or four, new, and then again those which had been discovered by M. von Hauer in Austria, ending by the following statement of the geological distribution of Foraminifera:—

| | Genera. | Species. |
|-------------------------|----------|----------|
| Palæozoic strata | 1 | 1 |
| Jurassic strata | 5 | 20 |
| Cretaceous strata | 34 | 280 |
| Tertiary strata | 56 | 450 |
| Existing epoch | 68 | 1000 |

So that it would appear that the genera and species were few in number and simple in structure at first, and increased both in number and complexity of structure from formation to formation, until they had obtained their maximum of development in the present seas. M. D'Orbigny even considered that this gradual advancement from simple to compound was more distinctly manifested in these minute beings than in any others, and that they are in consequence the best fitted for determining with precision the relative ages of geological strata. The following ten living genera, *Gromia*, *Rimulina*, *Conulina*, *Vertebrulina*, *Caudinia*, *Pavonina*, *Robertina*, *Cassidulina*, *Uniloculina*, and *Cruciloculina*, M. D'Orbigny named as not having been as yet discovered in a fossil state; and he gave the following view of the climatal distribution of the Foraminifera, which cannot fail to be very suggestive to the palæontologist also. Torrid Zone, 375 species; Temperate Zone, 350; Frigid Zone, 75: so that, as in Mollusca, the seas of hot climates are more productive of species of Foraminifera than those of colder regions.

M. D'Orbigny traces the history of these bodies from their first discovery in 1731 to the present time; and as a proof of the importance of the office they may have played in the formation of some geological strata (the houses of Paris and the pyramids of Egypt being in part built of rocks composed of Foraminiferous shells), he states that little more than an ounce in weight of the sand of the Antilles yielded 480,000 of these shells. M. D'Orbigny concluded, from his examination of the Foraminifera of the Paris basin, that they had lived in a hot climate, and had not been subjected to the wearing action of any current.

In explaining the distribution of the Foraminifera of South America, M. D'Orbigny points out how varied the groups are, under the influence even of chorographic differences,—the Foraminifera of the

southern shores of the Pacific differing from those of the southern shores of the Atlantic, and both from those of the equatorial region of the Antilles, from which fact he deduces the conclusions, that in the same sea, and in connexion with the same continent, different faunæ may exist at very small distances from each other; and further, that Tertiary basins, although different in their faunæ, may have been formed simultaneously, just as the material deposits are necessarily widely different in character at localities by no means very remote. Unquestionably the reasoning is good, and equally applicable to the geological deposits of all ages of the world*.

In his essay on the distribution of the Acetabuliferous Cephalopoda, he states, in reference to their present distribution, that 15 out of 16 genera are found in hot countries, 10 in temperate regions, and 6 only in cold; and he also concludes, from his inquiries, that these forms are more complicated as they inhabit hotter regions, and further, that it is probable the fossil genera lived under a high temperature. Taking account of this view of the subject, it is interesting to observe the other statement of M. D'Orbigny, that the Acetabuliferous Cephalopoda appeared first in the jurassic formation, when they were represented by the *Belemnites* and 6 other genera, including the existing genus *Sepia* and 3 other living genera, simultaneously with the vast numbers of *Ammonites*; that all disappeared except the genus *Belemnites* in the Cretaceous epoch, being represented, however, by different species; and that in the Tertiary strata, the *Belemnites* disappeared entirely, being replaced by the genus *Sepia* appearing for the second time, and the genus *Belopterus*, which appeared, only to pass rapidly away, as it is no longer a living genus. These are unquestionably very remarkable facts, and have on the one hand a tendency to support the doctrine which M. D'Orbigny so strongly supports, of the destruction of one creation and the production of another again and again at successive epochs, whilst, on the other, they may induce a pause in the decision of the palæontologist, as it seems difficult to conceive that any such genera as *Sepia*, *Sepioteuthis*, &c., could have been created so far back as the Jurassic age, and then have totally

* It must not be assumed from my remarks on D'Orbigny's labours in the *Foraminifera*, that I consider him to have arrived at his final results *per saltum*. Far from it, as in 1826 his object, as so well explained by Férussac, was simply to separate the microscopical *Cephalopoda*, as he then considered them to be, from the Siphoniferous genera with which they had been confounded. De Haan had previously* proposed such a separation, and founded upon it his *Siphonoides* and *Asiphonoides*; but D'Orbigny felt that there were other differences, and therefore proposed his more distinctive term *Foraminifera*. His 'Prodromus,' published at that time, was founded upon this view of the subject, and remained the standard of classification until Desjardins, in 1835, gave many reasons, deduced from careful observation, for separating the *Foraminifera* from the Mollusca entirely, and forming of them a totally distinct class, to which he gave the name *Symplectomères*. Desjardins therefore gave the impulse which has since led to the correct classification of these microscopical but most interesting animals, which have been shown, by the examination of the deep-sea soundings of the Atlantic, to be as active now as in ancient epochs in laying the foundations of future strata.

disappeared, to be *again created* in the Tertiary and existing epochs. I must again maintain that it is more natural to conceive that the link of connexion between the dead and the living has been kept up, although hitherto the region of their habitation, during the long period of time elapsed, has been veiled from observation.

I shall not attempt further to follow the able author of no less than fifty distinct treatises, some of vast magnitude and interest, and all full of ingenuity and knowledge; but I may notice him as the author of that nomenclature which is gaining ground rapidly; and in doing so I will quote, as illustrative of his method, the distribution of the Bryozoa-Cellulina, which he thus details:—

| | | Genera. | Species. | |
|-------------------------|------------------------------|---------|----------|----------------|
| Terrains Crétacés. | { Étage Néocomien | 1 | 1 | } 593 species. |
| | { — Aptien | 1 | 1 | |
| | { — Albien | 1 | 1 | |
| | { — Cénomanién | 11 | 26 | |
| | { — Turonien | 9 | 17 | |
| | { — Sénonien | 54 | 547 | |
| Terrains Tertiaires. | { Étage Suéssonien | 3 | 5 | } 109 |
| | { — Parisien | 12 | 24 | |
| | { — Falunien | 40 | 75 | |
| | { — Subapennin | 4 | 5 | |
| Existing Fauna. | { | 58 | 312.. | 312 |

The Bryozoa-Centrifugina, which form the other division of the class, he discovered in almost all the geological formations, and he gives their numbers thus:—

| | Genera. | Species. |
|----------------------------|---------|----------|
| In the Palæozoic | 10 | 66 |
| — Triassic | 0 | 0 |
| — Jurassic | 32 | 93 |
| — Cretaceous | 130 | 480 |
| — Tertiary | 32 | 101 |
| — Existing epoch | 26 | 80 |

And he concludes from the whole that there were *three centres* of development of the Bryozoa, the first two composed of B.-Centrifugina alone,—namely, one in the Carboniferous stage of the Palæozoic, and one in the Bathonian of the Jurassic,—and the other composed of both orders, Cellulina and Centrifugina, in the Senonian stage of the Cretaceous.

Having now, I trust, enabled every one to form a correct judgment of the great and varied abilities of M. D'Orbigny, in aid of whose researches the Society has twice awarded the proceeds of the Wollaston Fund, I will close my remarks with the following passage from the report of MM. Brongniart, Dufrénoy, and Elie de Beaumont, on his "Geology of South America," as it conveys a sentiment in which all our members will, I am sure, cordially concur:—

"The author's reserve, in treating upon a subject so vast and difficult, cannot but be approved, although no one can fail to perceive that the memoir of M. D'Orbigny has enriched science with a great number of new facts and with many ingenious speculations. New observations may hereafter lead to a modification of some of his theoretical views; but the merit will always be his of having considered a vast subject from a point of observation so elevated as must necessarily cause it to command attention, and lead the way to still further progress. We therefore propose to the Academy that it should express to the author the high satisfaction it has experienced in contemplating the indisputable advancement which has been made towards a knowledge of the geology of South America, by his courageous and persevering researches:—let me also add, towards a knowledge of the geology of all parts of the earth; for his great works on the Palæontology of France deserve such a commendation.

Having now, I trust, faithfully performed my duty towards those illustrious members whom we have lost, and who during their lives were active either in promoting the progress of our own science or in advancing the general knowledge of mankind, I will turn to a work not so embittered by painful recollections, and proceed to estimate the labours of the past year.

The present Session has been characterized by the excellence and importance of its Palæontological papers: the first was contributed by Professor Owen, who exhibited and described an almost entire lower jaw, with the permanent dental series, wanting only four middle incisors, of an Anoplotherioid quadruped, from the collection of the Marchioness of Hastings, and now forming part of the Palæontological collection in the British Museum.

From the equality of height of the crowns of the teeth, and their general character, Professor Owen considered the animal as belonging to that group of the Anoplotherioid family which includes the genera *Dichobune* and *Xiphodon* of Cuvier, the animal being of the size of Cuvier's *X. gracilis*. The author then described in detail the dentition of the specimen, and pointed out its difference from that of *Dichodon*, and of *Xiphodon*, as also its agreement with that of *Dichobune*, with which genus therefore he associated it provisionally, in the absence of a knowledge of the molars of the upper jaw; and, after a comparison with the *Dichobune leporina* of Cuvier, he formed it into a distinct species, *Dichobune ovina*, from the size of the animal. The *Dichobune cervina* of his 'British Fossil Mammals' he transferred, on the suggestion of M. Gervais, to the genus *Dichodon*.

Professor Owen then compared the genus *Xiphodon* with the genus *Dichobune*. The first had originally formed part of the genus *Anoplotherium*; but the species *A. medium*, Cuvier, afterwards called by him *A. gracile*, was subsequently separated by Cuvier, and made the type of a new genus *Xiphodon*, as *X. gracilis*, to which Gervais (in 'Paléontographie Française') afterwards added the *Xiphodon Gey-lensis*, and described the dental series of both jaws of the typical species

from a specimen obtained from the lignites of Debruge, near Apt. M. Gervais had given his reasons for considering the genus *Xiphodon* very approximate to *Hyopotamus*; but Professor Owen points out that both *Anthracotherium* and *Hyopotamus* differ from *Anoplotherium*, *Xiphodon*, and *Dichodon*, by the interrupted character of the dentition, which in the latter genera is continuous. The genus *Dichobune* had been also separated by Cuvier from the genus *Anoplotherium*, the species *A. minus* and *A. leporinum* having been transferred to this new genus, which is closely connected with the genus *Xiphodon*; it is, indeed, manifest that most able palæontologists have found it sometimes difficult to determine between such closely-allied genera, M. Gervais having in like manner transferred the species *Hyratotherium Robertianum* to the genus *Dichobune*. Professor Owen also made some interesting observations on the consequences of adopting the analogy of *Microtherium* or of *Anoplotherium* in determining the fore or back parts of the crown of the upper molar—an important point in settling the relations of a new genus,—he himself adhering to the *Anoplotherium*.

In respect to the first appearance of true Ruminants, Professor Owen remarked that the dentition of the upper jaw of the species *Anoplotherium murinum* and *A. obliquum*, referred by Cuvier to his genus *Dichobune*, must be known before the existence of true Ruminants in the Upper Eocene gypsum of Paris can be inferred. The following interesting remark closed his statement, and is worthy of careful attention; for, whilst it speaks of a formative force being transferred from one set of teeth to another, as an easy mode of effecting a transition, and shows how easily the Ruminant stomach might have been modified, it is impossible not to imagine how readily many transmutations might have been effected in the progress of time, without the aid of renewed creation. “No doubt the affinity of these small Anoplotherioids to the Chevrotains was very close; let the formative force be transferred from the small upper incisors to the contiguous canines, and the transition would be effected. We know that the Ruminant stomach of the species of *Tragulus* is simplified by the suppression of the psalterium, or third bag; the stomach of the small Anoplotherioids, whilst preserving a certain degree of complexity, might have been somewhat more simplified. The certain information which the gradations of dentition displayed by the above-cited extinct species impart, testifies to the artificial character of the order Ruminantia of the modern systems, and to the natural character of that wider group of even-toed hoofed animals, for which I have proposed the term Artiodactyla.”

The next paper by Professor Owen was one on a small Lophiodont Mammal from the London Clay, near Harwich. Professor Owen first points out the rarity, and usually fragmentary condition, of the remains of mammals found in Eocene beds below the Binstead, Gypseous, and Headon or Hordwell series, either in our own country or on the Continent, and illustrates this position by referring to the fossil evidence upon which the genera *Pachynolophus*, *Dichobune*, *Pro-*

palæotherium (Gervais), *Macacus* or *Eopithecus*, and *Hyracotherium* have been established. This last-named fossil genus was founded upon "the portion of a cranium with the molar series of teeth;" and as he was enabled to determine a new genus, named by him *Pliolophus vulpiceps*, on "an entire skull with the complete dentition of both upper and lower jaws, and a portion of the skeleton of the same individual, including the right humerus, the right femur, a great part of the left femur, the left tibia, and three metatarsal bones, apparently of the same hind foot," and many other recognizable and important portions of the skeleton, he justly states that "it is the most complete and instructive mammalian fossil of the age of the London Clay which has hitherto been discovered, and its study is replete with interest. It was brought to the British Museum by Mr. Colchester, being imbedded in one of the Roman-cement nodules of the London Clay, near Harwich. The osseous tissue is fossilized, and partly impregnated with pyritic matter. It is well known how rich the cement-nodules are in fossils; and, a fragment having been chipped off the present one, the attention of the workmen was arrested by the appearance of what appeared to them the head of a fox. The specimen then came into the possession of the Rev. Richard Bull, M.A., vicar of Harwich, who placed it in the hands of Mr. Colchester to obtain the opinion of Professor Owen on its true character and relations. By him it was recognized as a new species, forming the type of a new genus, which he has named *Pliolophus*, meaning to imply that it was nearer to the *Lophiodont*-type than its close ally the *Hyracotherium*: the whole name *Pliolophus vulpiceps*, or Fox-headed *Plioloph*, expresses the peculiar form already alluded to.

It is unnecessary that I should enter into the anatomical details, worked out, as they have been, with the usual skill of Professor Owen; but I may mention some of the results. One portion of the cranium approximates the specimen to the carnivorous type, whilst in other respects it follows the rule of the Hog, *Hyrax*, and *Palæothere*—resembling, in the proportions of the zygomatic arches, the *Palæotherium* more than any existing mammal. In a similar manner its approximation on the one hand to, and its divergence, on the other, from several other genera, such as the *Rhinoceros*, *Tapir*, Horse, and *Hyrax*, *Anoplotherium* and *Hyracotherium*, are minutely investigated, as are also the similarly partial approximation and partial divergence in affinities as exhibited by a conjoint comparison of the skull and teeth of *Pliolophus* and various other genera. Professor Owen then states that *Lophiodon*, *Pachynolophus*, *Pliolophus*, and *Hyracotherium* form so many sub-generic modifications of the same natural family of Perissodactyle Ungulates, and that in the comparative simplicity of their premolars, and the progressive approach to the molar type of the Chæropotamoids, the *Pliolophus* and *Hyracotherium* both exhibit a tendency to a closer adherence to the general Ungulate type.

Professor Owen then observes that, "in stating that these modified

Lophiodonts are the most artiodactyloid of the Perissodactyles, no particular hypothesis is advocated; there can be but one inference from this and the numerous analogous facts that have already been made known. So, likewise, in regard to the typical character of dentition as manifested by the number and kind of teeth, we find, in this last Eocene mammal which has come to light, a repetition of that remarkable adherence to a more general mammalian character. The older Oolitic mammals exemplify a tendency to a type of dentition of a still higher generality than the mammalian class." In this manner three genera of the Oolitic epoch resemble in their dentition the *general* Vertebrate type, whilst no less than 38 genera, belonging to the Eocene epoch, resemble in dentition the Mammalian Diphyodont type; but Professor Owen adds that "all general rules in organic nature have their exceptions, and differ in that respect from inorganic phenomena, in regard to some of the general laws of which no exceptions have been as yet discovered." If we consider this gradual change, from a more general type of vertebral organization to a more special type, to be the result of original creation, it seems difficult to understand the possibility of exceptions to any great law; but if it be considered only as the progressive modification of some type from a long series of ages of existence, it would seem quite natural and probable. The fact, however, though so strongly supported by Professor Owen, has been disputed in a paper, to be subsequently noticed, by Dr. Falconer, and the Professor has promised to consider at a future day the objection thus taken to his theory, which is unquestionably one of great importance in speculative Palæontology. A description of some of the bones of the extremities terminated this most interesting paper, and assisted to confirm the determination of the true position, and affinities of *Pliolophus*, and most probably of *Hyracotherium*, also in the Ungulate series.

The bones of the hind foot of an Iguanodon, discovered by Mr. Beekes in the Wealden-clay of the south coast of the Isle of Wight, afforded materials for another short paper by Professor Owen. After stating the result of his investigation of these interesting relics, he observes,—“guided by the analogy of the number of phalanges in the toes of the hind foot of the Iguana, we may infer that the three toes that are normally developed in the hind foot of the Iguanodon, are the second, third, and fourth; that the first or innermost is represented by a rudimental metatarsal, which was concealed beneath the skin of the foot; and that the fifth or outermost was entirely suppressed;” a modification of the hind foot, he adds, which is interesting by its analogy to the tridactyle hind foot of the *Rhinoceros* and *Tupia*, and still more so by its correspondence in the varying number of the phalanges, and their progressive increase from the inner to the outer toe, with the foot of birds,—a fact which naturally suggests a caution in respect to the habit of referring the many large tridactyle impressions found in the Wealden and other formations, to the class of Birds.

A large femur, also found in the Weald-clay of Sandown Bay, Isle

of Wight, was made the subject of a communication by Mr. Gibson, who stated that, though it had suffered much from pressure, Professor Owen had been enabled to state his opinion from a clay-model, that in all probability the bone was the femur of an *Iguanodon*, and if so, being the largest of its kind yet recorded, that it merited the attention of the Society.

Valuable as all these papers are, they afford only a small specimen of the continuous and successful efforts of the greatest Palæontologist of our day to enlarge our knowledge of the natural history of the earth at successive epochs; and it is most gratifying to know that the admiration we feel for such genius and skill is quite shared in by our Continental brethren; one proof of which may be derived from the following notice of a paper by M. Ed. Hébert, who has contributed an interesting memoir on a subject closely related to that which has engaged our attention, and, in the hands of Dr. Falconer, has produced such rich results. His principal object was to discuss the value of the genus *Coryphodon* of Owen, founded in 1846 upon a lower back molar, which in itself was very analogous to that of the *Tapir*, and consequently to that of the *Lophiodon*, but exhibited two transverse ridges instead of three, as in the *Lophiodon*. To this genus M. Gervais had correctly referred the *Lophiodon anthracoides* of Blainville, considering, however, that the genus could only be considered a sub-division of *Lophiodon*. To determine the question of the validity of the genus, M. Hébert examines the dental formula, and shows that, whilst the lower molars differ little from those of the *Lophiodons* and *Tapirs*, the difference from each of these genera being about the same, the upper molars constitute a distinct type from those of all other *Pachydermata*,—the *Coryphodon* being more separated from them in this respect, than the *Lophiodon*, the *Tapir*, the *Rhinoceros*, and the *Palæotherium* are from each other. The canines, separated from the incisors by a space less long than in the *Tapir*, are powerful and characteristic, resembling those of no animal, living or fossil. The incisors are strong and regular, with blunt points, having a singular resemblance to those of *Anthracotherium*. M. Hébert concludes the comparison by observing that the formation of this genus from a single tooth is an example of the rare sagacity of Mr. Owen, and that, so far from any doubt being thrown on the validity of the genus *Coryphodon*, it cannot be doubted that future researches will bring to light new forms, intermediate between the *Coryphodon* and the *Lophiodon*. He has also determined the existence of two species of the genus, namely, the *Coryphodon eocænus* of Owen, found by M. Hébert in the lignite bed of the Soissonnais, and another called by him *C. Oweni*, from the conglomerate of the Plastic Clay, or lower in the series. The name *C. anthracoides*, is of course abandoned, as merging in *C. eocænus*. The *C. Oweni* was larger than the *Tapir* of India; and the *C. eocænus* must therefore have been an animal of large stature. M. Hébert then gives a tabular view of the mammiferous fauna of the Lower Tertiaries of France:—

| Mineral Condition | Physical Formation. | Mammifera observed. | |
|---|--|---|---|
| Gypsum | Fluvio-lacustrine | Fauna very rich ; Anoplotherium, Palæotherium, &c. the details not given. | |
| Calcaire de Saint-Ouen | Lacustrine | Anchilopus Desmaresti, <i>Gervais</i> , wrongly quoted as from the Calcaire Grossier. | |
| " " " | Fluvio-Marine... | Ossiferous conglomerate at the junction of these beds not yet studied. | |
| Sables de Beauchamp.. | Marine..... | None. | |
| Upper Calcaire Grossier | Fluvio-Marine... | Lophiodon Parisiensis, <i>Gervais</i> ; Pachynolophus Duvalis, <i>Pomel</i> ; P. Prevosti, <i>Gervais</i> ; Dichobune Robertiana, <i>Gervais</i> ; D. suilla, <i>Gervais</i> ; and others, as yet undetermined. | |
| Middle and Inferior Calcaire Grossier ... | } Marine..... | None. | |
| Conglomerate of Mont Bernon | } Fluvatile... { | Pachynolophus Vismaci, <i>Pomel</i> . Several species of Lophiodon not yet described ; Carnivores. | |
| Soissonnais Sands. | { Upper, or of Cuisse Lamotte..... | } Marine..... | None. |
| | { Lignites | { Saltmarsh ... { | Coryphodon eocænus, <i>Owen</i> . Paleonictis gigantea, <i>Blainville</i> . |
| | { Plastic Clay | | None. |
| | { Conglomerate of the Plastic Clay | { Fluvio-Marine { | Coryphodon Oweni, <i>Héb.</i> ; several other Pachyderms and Carnivores and a Rodent. |
| | { Inferior, or of Bracheux | } Marine..... | Arctocyon primævus, <i>Blainville</i> . |
| Limestone and marl with <i>Physa gigantea</i> | } Lacustrine .. | None. | |
| White Sands of Rilly-la-Montagne | } | None. | |

Old-established labourers in Palæontology have not failed to contribute their quota towards the advancement of palæontological science; for example, Sir Philip Egerton has supplied an interesting paper on Fish Remains from the neighbourhood of Ludlow, which deserves special attention. He justly states the difficulty of the subject, and observes that little has been discovered, since Agassiz determined the Ichthyic affinities of the Cephalaspid remains in England, to have enabled even that great naturalist to advance a positive opinion as to their true place in the scale of nature. Agassiz, whilst referring two species, namely *Cephalaspis Lewisii* and *C. Lloydii* to the genus which he had originally founded on *C. Lyellii*, indicated the possibility that they might hereafter become the type of a new genus; this change has been effected by Br. R. Kner, who formed the genus *Pteraspis*, a genus accepted by Professor Huxley and Mr. Salter, though on different grounds to those on which Kner's determination was made. With, therefore, every necessary reserve upon so difficult a point, Sir Philip has been able to establish, even from the imperfect materials furnished him, no less than three new species, namely *Cephalaspis*

Salweyi, *C. Murchisoni*, *C. ornatus*, restoring therefore to the genus a stability equal to that it had formerly obtained,—and one new genus and species, *Auchenaspis Salteri*, founded on a specimen perfect in every respect, and yet in size not larger than a fourpenny-piece—a genus closely allied to *Cephalaspis*, but yet structurally distinguished from it.

It is curious and worthy of notice, that the ichthyological portion of this subject has also engaged the attention of Professor Huxley, who has already attained a high place in the ranks of our Palæontologists. Reviewing the question of the affinities of *Cephalaspis* and *Pteraspis*, in a paper read before our Society, he refers to the opinion expressed by Kner, that *C. Lloydii* and *C. Lewisii* should be separated from the other species belonging to that genus, and placed in a new genus, *Pteraspis*, which, however, he considered a genus of Cephalopods, and not of Fishes. Roemer again more recently expressed an opinion that the *Pteraspides* are Crustaceans, but, after a careful microscopical examination of the shields of *Cephalaspis* and *Pteraspis*, Professor Huxley has fully established the ichthyic character of *Pteraspis*, whilst at the same time he proves its just claim to be considered a distinct genus; so that this paper was a valuable confirmation of that of Sir Philip Egerton.

The importance of this inquiry of Professor Huxley had been stated by anticipation, and with his characteristic modesty, by Sir Philip Egerton, who observed, towards the close of his remarks, “much remains to be done with reference to the structural anatomy and true affinities of this curious family—subjects far beyond my grasp, but which I trust ere long will be grappled with by Professor Huxley, who has already bestowed some time upon them, and than whom no one is better qualified for bringing the inquiry to a successful issue.”

Associated with the specimens described by Sir Philip Egerton, were portions of jaws resembling *Plectrodus mirabilis* rather than *P. pleiopristis*, an Ichthyodolite resembling *Onchus Murchisoni*, and another, hitherto undescribed, which differs from the genus *Onchus* as now restricted, and in some characters approximates to the spines of *Ctenacanthus* and *Erismacanthus*; Sir Philip, however, offers a proper caution as to a reliance upon the forms of spines in determining specific differences. Sir Roderick Murchison added a few useful remarks on the relative position of the Ludlow strata which had supplied the fossils described by Sir Philip Egerton, as a note to his paper. In the section of the railway-cutting north of Ludlow, some of the highest beds of the Ludlow Rock have been brought, by an up-cast, immediately in contact with the Old Red Sandstone, constituting a small insulated mass, which is younger than and distinct from the bone-bed of the Upper Ludlow Rock, described in the ‘Silurian System;’ for, whilst the bone-bed is overlaid by the Downton-castle building-stone and other grey strata which constitute the lower portion of the tilestones, the Railway-band, about 6 feet thick, is conformably surmounted on the south-east by micaceous sandstone and red shale or marl. Though, however, higher in the series, this thin

band still contains some characteristic fossils of the lower course, such as *Plectrodus*, *Onchus Murchisoni*, and *Singula cornea*: it contains a large majority unknown in any inferior stratum, viz.—*Cephalaspis ornatus*, Eg., a species of which Sir Philip expresses a belief that future specimens may reveal further characters, and lead to its union with *C. Murchisoni*; *Auchenaspis Salteri*, Eg.; *Onchus* or *Byssacanthus*; *Pterygotus anglicus*, Ag., and *Eurypterus pygmaeus*, Salter;—the last two fossils having been recognized by Mr. Salter, who will describe them in the Survey Decades. Sir Roderick points out the manner in which the strata are so obscured by drift, that they can only be discovered here and there in the river-bank, where the water is very low, and hence suggests that the Railway-band, though its intermediate range is concealed by detritus, may yet be discovered in the banks or in the bed of the Tems. A fossil-band, called the Grit-bed, composed of a whitish-grey micaceous sandstone, was discovered by Mr. Lightbody higher in the series: it contains several of the fossils which have been mentioned, together with fragments of crustacea and coprolites; and, as amongst its fossils some of those most characteristic of the lowest of the bone-beds are found, it might at first be supposed to exhibit, though associated with red and green marls, the last remnant of Silurian life, were it not that other fossils show that it marks a passage upwards into the Old Red or Devonian system, and forms, in fact, the uppermost layer of the tilestones, whilst the red marls, sandstones, and concretionary layers which follow, with the *Cephalaspis Lyellii*, *Pteraspis Lloydii*, &c., form the great overlying masses of Old Red Sandstone. The determination of the true generic position of fossils must always be an important element towards the accurate identification of strata; but with every aid there must be many difficulties in settling the true age of strata which are connected with a drift-period; and the observation, therefore, of Sir Roderick in respect to the tilestones of Shropshire and Herefordshire, “that they may be classed either with the Silurian or the Devonian, according to the predominance of certain fossils,” is both just and philosophical.

A conjoint paper by Sir Philip Egerton and the Rev. P. B. Brodie contains an account of the discovery, by the latter geologist, of a new species of *Palaeoniscus* in the Upper Keuper Sandstone, at Rowington, near Warwick, and a careful ichthyological description of it by Sir Philip. In this he points out the difference, as regards the remote position of the dorsal fin, which separates it from all the other known species of the genus except the little *P. catopterus* of Roan Hill, county of Tyrone, Ireland, formerly considered to belong to the New Red Sandstone, but now transferred, as other supposed portions of the same formation have been, to the Permian. Though the specimen was not perfect, Sir Philip considered it sufficient to prove that it was a true heterocercal fish, and not one exhibiting a transition between the heterocercal character of Permian and other earlier strata, and the homocercal character of the Liassic fish. The dorso-ventral scales are arranged in gentle curves, which give an appearance of much elegance to the species, which is named by Sir Philip

P. superstes, as being probably the last surviving representative of a genus "which occupied so important a place in the fauna of the Carboniferous and Permian epochs." The Rev. Mr. Brodie also states that "another and entire fossil fish has been obtained from the Keuper Sandstone, but that the possessor has not yet been persuaded to place it in the hands of a palæontologist for examination and description." He mentions also the discovery of more vegetable remains, amongst which are several which appear to be the *calyces* of some flowering plant. The occurrence of so many vegetable impressions in beds so closely associated with those containing the fossil fishes in this locality, and the similar occurrence of *Posidonia minuta*, now considered by some able palæontologists as a Crustacean (*Estheria*), seem to suggest a freshwater habitat for the genus *Palæoniscus*; and I will only add that the analogy in anatomical structure of extinct with existing fishes is not always sufficient to prove that the medium in which they lived must have been the same.

The next paper was one pregnant with interest, as it brought before us proofs of a terrestrial fauna in the Purbeck region, which had been previously represented only by the fossil mammifer named and described by Professor Owen as *Spalacotherium tricuspides*, a small insectivorous form, referred with some hesitation to the Placental series. It was discovered by Mr. W. R. Brodie in one of the dirt-beds of Durdlestone Bay, Purbeck; and the same observer afterwards found other mammalian remains, also in a dirt-bed, which he forwarded to Professor Owen for description. Mr. Samuel H. Beckles, who had already gained much experience by his researches in Sussex and the Isle of Wight, now entered on the field, and being encouraged and assisted by the judicious advice of Sir C. Lyell, who has always maintained that the non-discovery of the remains of terrestrial animals is no decided proof that they had not existed, proceeded to Swanage to commence that close and steady search for mammalian remains which has resulted in the discovery of what would be considered a rich local terrestrial fauna, even in the present state of the earth, some reptilian remains having been mixed with those of the mammals. The whole collection has now been submitted to Professor Owen for his final examination and description; but in the first instance they were wisely sent to Dr. Falconer, who, being able—as a consequence, I am sorry to say, of frequent confinement to his house by ill health—to devote his immediate attention to them, was in a condition to give Mr. Beckles useful hints in the progress of his search. Dr. Falconer soon recognized no less than seven or eight genera of Mammalia, some of them unquestionably Marsupials, both predaceous and herbivorous, others, in Dr. Falconer's opinion, more probably Placental Insectivora, having affinities, more or less remote, to existing types. Having been requested by Mr. Beckles to describe one of the most remarkable genera, as a contribution to the Supplement of Sir C. Lyell's 'Manual,' then about to be published, Dr. Falconer favoured the Society with a more detailed statement of the result than was necessary for the former purpose.

The genus *Plagiawlax* (being an abbreviation of *Plagiulacodon*,

from *plagios*, “oblique,” and *aulax*, “groove,” in reference to the diagonal grooving of the premolars) has been established by Dr. Falconer; and he has been already enabled to distinguish two species, one named *P. Becklesii* in commemoration of the zealous discoverer of the specimens upon which it is founded, and *P. minor*. Dr. Falconer points out that the coronoid process in *Plagiaulax* resembles more that of the predaceous Marsupials, and especially of the Ursine *Dasyurus*, than it does that of the herbivorous families, differing in a marked degree from the elevated strap-shaped coronoid of *Hypsiprymnus*, though at the same time being less elevated than in the predaceous genera whether marsupial or placental; but, after a more careful investigation of the question of affinity in every direction, he concludes that *Plagiaulax* may be considered as a marsupial form of Rodent, constituting a peculiar type of the family to which *Hypsiprymnus* belongs. The genus must have presented a form to which there is nothing exactly similar in living marsupials.

It may, he observes, for aught which can be asserted to the contrary, have had the volant habits of the Flying Phalangers, and have flitted from tree to tree among the Oolite forests by means of parachute-like folds of the skin. The species were probably herbivorous or frugivorous like the Kangaroo-rats; but there is nothing in their teeth to show that they were either insectivorous or carnivorous. The largest species was about the size of a squirrel, the other much smaller. Professor Owen has designated another form by the generic name of *Triconodon*, so that at present there are three described Mammalian Purbeck genera—*Spalacotherium*, *Triconodon*, and *Plagiaulax*. Dr. Falconer also points out the remarkable resemblance between the molar teeth of *Plagiaulax minor*, and those of the Triassic genus *Microlestes antiquus* of Plieninger; and this resemblance may help to settle the true character of the *Microlestes*, supposed by some to be predaceous, by others to approximate to an omnivorous or omnivoro-insectivorous type.

Dr. Falconer further remarks in respect to the speculative views of palaeontologists,—that, whilst they do not consider that there is any satisfactory evidence of a progressive serial development from the lower to the higher forms, there has been another form of serial progression, namely, from the general to the special, the animals of the older period being more perfect in respect to an archetype, or, as it may be called, a normal type, whilst by degrees there is a divergency from this archetype, in order to assume a more special character, and to progress towards a special adaptation to new circumstances or conditions of life. Now *Plagiaulax* is, as Dr. Falconer observes, the oldest herbivorous mammal yet discovered; and yet, so far from adhering to the general archetype, it is far more specialized than any of the Marsupials, whether fossil or recent, exhibiting characters, at the earliest epoch, which ought rather to have been found in animals of the existing epoch,—a fact, therefore, which is entirely at variance, in his opinion, with the theoretical views to which I have alluded in speaking of the paper of Professor Owen. The case is one of difficulty; and I will only repeat that it cannot be explained

by the supposition of any exceptions to a primary law of nature or of organization.

Two other communications of Dr. Falconer were on the species of Mastodon and Elephant found fossil in Britain,—the first paper relating to the Mastodon—remains of the Norwich or Red Crag, all of which are referred, so far as present knowledge permits their identification, one species—the *M. (Tetralophodon) arvernensis* of Cuvier and Jobert, a pliocene form. In a similar manner he examines the species of Elephants, and shows that, associated with the *Mastodon arvernensis*, occur *Elephas meridionalis* and *E. antiquus*, as well as *Rhinoceros leptorhinus* and *Hippopotamus major*,—an association the same as that of the Val d'Arno, or of the Subapennines; and this of course excludes the opinion which had been advocated by many, that there was really only one species of Elephant, *E. primigenius*, extending over both miocene and pliocene formations.

So far, indeed, from admitting only one species of Elephant in the deposits of Europe, and therefore assuming that the same species had been contemporary with two species of Mastodon, Dr. Falconer considers that he has fully established four distinct species, and further proved that the several species of Elephant, as well as the species of Mastodon, are limited to peculiar formations in so marked a manner as to justify him in ascribing a higher value to them and to other air-breathing animals, for determining geological epochs, than to the relics of Mollusca or other marine animals.

To effect so important an object as is implied by this deduction, it was manifestly necessary that the most careful scrutiny should be applied to the determination of the true characters both of genera and species. In treating of the Mastodon, Dr. Falconer had, for example, pointed out that the obscurity which had crept over the determination of the faunæ of the Miocene and Pliocene periods was the necessary result of the fusion of several really distinct forms, belonging to different geological ages, into one species—the *Mastodon angustidens*; and in like manner he shows that the same confusion has existed in reference both to the geographical range, and period of existence as a species, of *Elephas primigenius*, or the Mammoth, which, having been quoted as existing at the time of the deposition of both the lower and upper pliocene beds, and also, when the post-pliocene glacial gravels were distributed, must have continued its existence over a vast extent of time and space, in spite of the convulsions which had attended the elevation of the Alps, Apennines, and Pyrenees, and given rise to the present geographical contour of the European area. In order to unravel this confused jumble of many species into one, Dr. Falconer points out the peculiarities of dentition, and, assuming these peculiarities as permanent, or, in other words, as depending on an organic law, not on a mere casual modification, he explains the characters on which several subgenera have been established, and shows that, just as *Tetralophodon arvernensis* had been separated from *Mastodon (Trilophodon) angustidens*, so also must *Elephas (Euelephas) primigenius* be separated from *Loxodon meridionalis*, *L. priscus*, and *Euelephas antiquus*, however near to each other in some respects they may be.

By this reasoning, then, it appears that the following genera are grouped together in the older pliocene deposits of several important localities: viz. Piedmont and Lombardy—*Trilophodon Borsoni*, *Tetralophodon arvernensis*, *Loxodon meridionalis*, *L. priscus*, *Euelephas antiquus*, together with *Rhinoceros leptorhinus* and *Hippopotamus major*. In the Subapennine beds of the Val d'Arno, in Tuscany—*Tetralophodon arvernensis*, *Loxodon meridionalis*, with the same *Hippopotamus* and *Rhinoceros*. Near Chartres in France—*Loxodon meridionalis* with the same *Hippopotamus* and *Rhinoceros*. In the Crag deposits of the Eastern coast of England—*Tetralophodon arvernensis*, *Loxodon meridionalis*, *Euelephas antiquus*, associated at Cromer and other places in Norfolk, as well as in the Valley of the Thames, with *Rhin. leptorhinus*, and *Hipp. major*; so that the resemblance between the two extreme localities is even greater than between either of them and the intermediate.

On the north of the Alps, the regular characteristic fauna of the Pliocene epoch becomes confused by the introduction of species foreign to it, proceeding from the erratic drift, in some cases a glacial drift; and this has been the case also in proximity with the newer gravels of England, so that the *Euelephas primigenius*, the Mammoth of the Siberian glacial period, the *R. tichorhinus*, and the Musk Ox (*Bubulus moschatus*) of the Post-pliocene fauna have been accidentally mixed with the fauna of the Pliocene. Whilst, however, thus separating the fauna of the true Post-pliocene beds from that of the Pliocene, Dr. Falconer considers that the chronological subdivision of the Upper Tertiaries into Older Pliocene and Newer Pliocene or Pleistocene is untenable, as he considers too great a stress has been laid upon shell-evidence—at the same time stating that he is far from supposing that all the species of this remarkable fauna ranged equally throughout the area, as it is at least probable that some were peculiar to the south, and others to the north. The apparent restriction, indeed, of *E. primigenius* to the region north of the Alps, in Europe, and again to the Northern and Central States of North America, is a fact of great importance, whilst the occurrence of the *Hippopotamus* gives a fair indication of the climatal and physical conditions of the country.

A short paper of Mr. W. Bollaert, F.R.G.S., on the occurrence of bones of *Mastodon* in Chili, was communicated by Professor Owen, who states that the fragments of bone taken from the Lake of Taguatagua, 45 leagues south of Santiago de Chili, are parts of a femur and tibia of a *Mastodon*, probably *M. Andium*, Cuvier. Mr. Bollaert observes that few instances of the discovery of fossil bones on the western side of the Andes have been recorded, and that he had been unable to discover any traces of such bones, either on the Isthmus of Darien, where many railway-cuttings were in progress, or on his journey southward to Chili, until his friend, the British Consul at Santiago, Mr. George Smith, presented him with the above specimens which he had himself taken from the Lake Taguatagua. The lake is 2300 feet above the bed of the Pacific Ocean, and is surrounded by very high hills, called the Borbollon, of volcanic origin, the highest peak rising to the height of 7000 feet above the margin of the

lake. It receives no streams from the mountains, but, being supplied from springs, is generally as full in summer as in winter, and appears to Mr. Smith to be the exhausted crater of a volcano. In cutting a ditch from the lake towards the mountains, the fossil bones were found at the depth of 30 feet, the first animal discovered being almost perfect, excepting the head, and another skeleton of smaller size being very near it. Mr. Smith found fossil branches of trees in the same trench; and as its width was only 12 feet, he naturally concluded that a wider excavation in the alluvial soil would have yielded the remains of other individuals, and in consequence suggests, "may not herds of these creatures have been destroyed whilst feeding on what at that time was an extended plain?" The teeth of one of these animals are in the museum at Santiago; and there can be no doubt that the skill of a Falconer would be enabled to determine whether, in South America also, there is a difference between the Mastodons of the East and West, the *M. Audium* having been found both east and west of the Andes, in Peru and Chili, and the *M. Humboldtii* in Buenos Ayres and Brazil, or entirely to the east. Without doubt, this wide distribution in the ancient fauna of a type of organization so comparatively restricted at present in its range, is one of the most curious natural-history phenomena which the researches of geology have brought to light.

In the class Crustacea, two additions have been made to our knowledge, both of which are interesting, as tending to approximate the faunæ of past epochs to that of the present,—a remark I have frequently on preceding occasions been led to make. The one is a Decapod from the Lias Bone-bed, described by Mr. C. Gould of the Geological Survey, to which it had been confided for examination by Mr. E. Higgins, of Birkenhead. Mr. Gould after describing carefully the specimen, investigates the affinities of the fossil individual to known genera and species, and points out in what respects it resembles, and in what it differs from, the several great divisions of the Macrura; he then states that, although there is an affinity in some respects with the genera *Nephrops* and *Scyllarus*, he does not think the evidence sufficient for assigning it to those or any existing genus of Macrura, and he therefore constitutes a new genus for its reception. The names assigned to it are *Tropifer laevis*,—the generic term (from *τρόπις*, "keel") expressing the keeled character of the carapace, and the specific its general smoothness. The eyes are large and remote, and the abdomen flattened and sculptured.

The next was derived from the Coal-measures, and is the result of the examination, by Professor Huxley, of three specimens, two of which belong to Mr. R. S. Cooper, of Bilston, and the third, being the most perfect, to the Manchester Museum, which were obtained from the Coal-shales at Midlock Park Bridge. Professor Huxley describes minutely the structural peculiarities of the specimens, and explains the difficulty of even deciding "which end was the head, and which the tail, and whether the surface exposed to view was the ventral or the dorsal." Assuming the dorsal surface to be in view, his first impression was, that the form combined the characters of several orders

of *Crustacea*. Taking, however, into account all the objections to so anomalous an interpretation, he next reversed his hypothesis, and assumed "the quadrilateral disk to be the head, the hemispherical disk to be the caudal extremity, and the exposed face to be ventral,—a supposition which, though still not free from difficulty, exhibited, on a comparison of the specimens with the *Mysis* or Opossum-shrimp of our own sea, such curious points of resemblance as could not be considered merely accidental; and he therefore concludes that the *Pygocephalus Cooperi*, which is the name he adopts, is probably more nearly allied, notwithstanding an approximation in some respects to the *Squillidae*, to the *Mysis* than to any other existing form, that it is therefore a Podophthalmous Crustacean, and may safely be assigned a place among either the lower *Decapoda* or the *Stomatopoda*, affording the first certain evidence of the existence of *Podophthalma* at so early a period as the Carboniferous epoch.

In another paper, Professor Huxley described a new species of *Plesiosaurus*, procured at Street, near Glastonbury, and now in the Museum of Practical Geology, Jermyn-street. As this species will be described at length in the Decades of the Geological Survey, the object of Professor Huxley was principally to point out the peculiarities of the atlas and axis, and of the cranium of that genus. The species resembles most *P. Hawkinsii*, and is about the same size, being between seven and eight feet long; but it has 53 cervico-dorsal vertebrae, of which 30 are cervical, whilst in *P. Hawkinsii* there are 31 cervical, and at least 23 dorsal. The species is therefore characterized as having 53 cervico-dorsal vertebrae, by a cranium not more than $\frac{1}{12}$ th of the length of the body, the 30 anterior vertebrae being fully, or more than, four times the length of the cranium. It has been named *P. Etheridgei*. The atlas and axis are (as stated by Professor Owen) to be characteristic of the genus) ankylosed; but their structure is very different from that exhibited in the genus *Ichthyosaurus*, and more nearly resembles the corresponding parts of the Crocodile.

Professor Huxley then pointed out the many points of structural correspondence between *Plesiosaurus* and *Telcosaurus*, and questions the accuracy of the very backward position of the posterior nares ascribed to *Plesiosaurus*, which would be in opposition to such an analogy, as the posterior nares in *Telcosaurus* are far more forward than in *Gavialis*, and in the Gavial more forward than in the Crocodile. He thinks it therefore more probable that the so-called posterior nares of *Plesiosaurus* correspond with the deep fossa on either side of a prominent median ridge visible on the under surface of the basi-sphenoid of *Telcosaurus*. Some other structural analogies between *Telcosaurus* and *Plesiosaurus* were noticed; and Professor Huxley stated that in many respects the *Telcosaurus* appeared to afford a link, before not noticed, between the long-necked *Enaliosaurus* and the existing Crocodile, a conclusion in the interest of which, when the relations of time are considered, the genus *Plesiosaurus* must manifestly share.

In respect to the ancient flora, Mr. Salter has submitted a notice

of some terrestrial plants from the Old Red Sandstone of Caithness, the specimens being, however, merely fragments, and, as such, only capable of an approximate determination. The best have been lent for examination, by Mr. John Miller, of Thurso; and Mr. R. Dick has materially added to the discoveries. Similar plants have been found at Wick by Mr. C. W. Peach, and by Dr. Hamilton in Orkney. All the collections have passed under the observation of Mr. Salter. The fossils are preserved in hard, grey, sandy flag-stones, many of which are marked by Annelide borings; and it was suggested by the late Hugh Miller, that these strata had been accumulated on an extremely level muddy shore: some appear to have been fragments of large stems, occasionally three feet long, and are straight and finely fluted; others, which are curved and occasionally branched, were probably roots. They are highly bituminized; and divided by oblique lines, evidently due to mineral structure. From compression, the silex stands out in relief, and the resulting impressed lines may be mistaken for marks of organic structure, similar lines noticed by Dr. Hooker in calamites from near Lerwick having been ascribed by him to "pressure during silicification." The large stems are considered by Mr. Salter to have belonged to Coniferous wood, and the structure, or thick woody envelope, surrounding a central pith, to be allied to that of the *Dadoxylon* of the Coal-measures; and in confirmation of his opinion, Mr. Salter refers to the authority of Professor Quckett, who examined for him microscopically some sections, and found the ordinary Coniferous structure,—namely wood-fibres dotted with disks, which appear to have been in alternating double rows, as in the modern *Araucaria*. The dotted structure distinguishes the specimens from other fragments of fossil-wood without disks, described by Professor Unger. Some smaller branches, bearing branchlets at intervals, are referred to the same plants. Some of the supposed rootlets are marked by tubercles, as are the roots of many Conifers, and cannot, in Mr. Salter's opinion, be ascribed to marine plants. Of Lycopodiaceous plants, Mr. Salter names one *Lycopodites Milleri*; and the other he thinks may be *Lepidodendron nothum*, Unger, though not exactly agreeing with the figure given by Unger, which, however, appears to represent the cicatrices, not the leaves themselves. Professor Unger considered his plants as constituting a new type, and they came from the Upper Devonian of Germany, whereas the strata from which the fossils described by Mr. Salter were derived have been determined by Professor Sedgwick and Sir R. I. Murchison to belong to the Middle Devonian, and were associated with the genera of fishes *Dipterus* and *Diplopterus*. An interesting note was appended by Mr. John Miller, descriptive of the Devonian beds of Caithness, which had yielded these plants.

Mr. C. J. F. Bunbury, F.R.S., has taken advantage of an interesting fossil specimen of the genus *Neuropteris* from the Coal-measures of Lancashire, to throw some light upon the true character of that genus. He points out the extreme rarity of specimens of young half-expanded fronds of Ferns, showing the characteristic circinate vernation. Those hitherto figured have belonged to the genus

Pecopteris; but the present specimen exhibits a well-marked example of the circinate condition in *Neuropteris*, and proves that it did not belong to the Coniferous order. The only flowering plants which can be compared with Ferns in this respect are the *Cycadææ*; and Mr. Bunbury admits the difficulty of deciding, in the absence of fructification, whether *Neuropteris* may not have belonged to that family, though it is far more probable, from all the observable characters, that these plants were true Ferns; the present specimen he considers to belong to *N. gigantea*. Mr. Bunbury concluded his paper by stating that the genus is principally characteristic of the Coal-measures,—no genuine species from a formation later than the Trias having come under his notice, whilst the Oolitic species referred to the genus by Lindley and Hutton do not agree with its characters. *N. Loshii* and *N. tenuifolia* appear, he observes, to be common to the Carboniferous and Permian systems; and he adds that the species have been too much multiplied by describing the ordinary and possible variations in the same frond as distinct species. I need not add that this short addition to our more critical knowledge of an important fossil genus of plants exhibits Mr. Bunbury's well-known botanical skill and accuracy of judgment.

Foreign paleontology.—Of all living animals, the Edentata are perhaps second only to the Marsupials in the interest attached to their organization and habits; but, unlike the Marsupials, they possess another claim to our admiration, in the fact that they have not as yet been traced beyond what may be considered the natural terrestrial range of their distribution. We can still study the wonderful organization and the singular habits of the Armadillo and the Sloth in the original cradle of the first birth of the order; and Professor Owen has pointed out to us that they are but the relics of a larger fauna characteristic of South America, and once enriched by the *Glyptodon*, the *Mylodon*, and the *Megatherium*. A memoir upon the *Glyptodon*, by Professor Owen, has appeared in our Transactions; and my object at present is to bring under your notice a memoir by M. L. Nodot of the Academy of Dijon, and published in its Transactions.

M. Nodot first reviews the history of the progress of knowledge in respect to the peculiar form of organization of the Edentata, and specially of the *Glyptodon*, and justly remarks that it was not till the great Cuvier had given so powerful an impulse to the study of fossil organic remains, that travellers began to bring home specimens of such relics from distant countries. We are all aware with what skill Professor Owen treated the investigation into the Osteology of the remarkable genus *Glyptodon*; and M. Nodot states correctly that he recognized and named, from specimens in the Museum of the College of Surgeons, four species, to which he added afterwards, without describing it, a fifth species; but M. Nodot adds that the number has now been, to his own knowledge, tripled. He then proceeds to describe these species, making a wise reservation when he observes that, not being acquainted with the descriptive characters of the three species named by Dr. Lund *Hoplophorus euphractus*, *H. Scloti*, and *H. minor*, it is possible that he may have sometimes applied new

names to some of those species. He further observes that one of the four species described by Professor Owen was not, in his opinion, sufficiently known to be accurately determined, and ought perhaps to have been transferred to a separate genus.

M. Nodot had the advantage of examining a very valuable collection of remains of Edentata, brought home from South America in 1846, by Vice-Admiral Dupotet, and which his widow, in conformity with his wishes, conferred upon the Museum at his untimely death. The larger portion of his collections had been previously deposited in the Museum at Paris; but this generous contribution to the treasures of a provincial museum consists of 2000 fragments, more or less valuable, but which were all confusedly packed together in the chests containing them. The task of identification and restoration was necessarily very great; but M. Nodot carried it on vigorously and successfully, adopting as rules for preparatory selection—1st, the colour of the fragments; 2nd, the thickness of the fragments; 3rd, the peculiar markings or figured designs upon them; 4th, anomalous forms, tubercles, &c.; by which arrangement the whole number of fragments were reduced into 30 groups, and the examination greatly simplified, whilst M. Nodot was enabled by the same means to compare the specimens at Dijon with those at Paris, and thus to supply many deficiencies in the parts of the former by castings from analogous portions amongst the Paris specimens.

Having thus completed the reconstruction of his species, M. Nodot compares it with the *Glyptodon clavipes* of Owen, and notes the following differences:—

1st. The carapace or cuirass is much more convex than in *Glyptodon clavipes*, and resembles the form of a truncated pear more than of a cylinder,—a difference which may be sexual, but in that case would mark the specimen as having been a female.

2nd. Nearly all the osselets which compose the cuirass are hexagonal, whilst in *G. clavipes* they are pentagonal. Besides, the circular or ovoidal markings, situated on the front of the central line of the osselets in the *G. clavipes*, are on the posterior extremity in the Dijon species.

3rd. The tubercles which form a border to the carapace of *G. clavipes* are all alike in form and size, and are supported on two rows of osselets, whereas in the other species the tubercles are disposed in series of different forms, and several are articulated with only a single row of osselets, their edges being angular and imbricated, which gives a segmentary character to the sides of the animal.

4th. The carapace of the *G. clavipes* exhibits not a trace of an anterior or posterior buckler, whilst it is distinctly visible on the lower margin of each side of the carapace of the other.

5th. The tail of the *G. clavipes* is composed of pieces strongly articulated, and intimately connected together, which form a homogeneous and inflexible sheath, which envelopes the vertebræ of the tail, whilst in the other the tail is merely annulated and extremely flexible, both laterally and downwards, having also a series of supplementary tubercles articulated on the axial line of each ring, of

which the probable object is unknown. On the basis of these distinctive characters, particularly on the flexibility of the tail, M. Nodot considers himself justified in establishing a new genus, to which he has given the name *Schistopleurum* (from *σχιστός*, cut, *πλευρόν*, side), in reference to the segmentation, by which character it is approximated nearer to the genus *Armadillo* than to the *Glyptodon*. I do not think it necessary to follow M. Nodot into minuter details, from the consideration of which he has established three species of his new genus, *S. typus*, *S. genimatum*, *S. tuberculatum*, and added to the genus *Glyptodon* five, viz. *G. subelevatus*, *G. elevatus*, *G. gracilis*, *G. quadratus*, *G. verrucosus*: but I may add, he considers that the genus *Hoplophorus* of Lund should be retained, as being distinct from the genus *Glyptodon* of Owen, being characterized by its club-shaped tail; and he therefore names the *G. clavicaudatus* *H. clavicaudatus*, which, however, appears objectionable, as a generic peculiarity cannot be properly used as a specific designation. This genus is remarkable for its great size, M. Nodot remarking that he has only observed two species, *H. euphractus*, and *H. Selloi*, both of which were of the size of an Ox; and it may well be understood how useful the short club-shaped tail must have been in supporting the weight, probably more than 4000 lbs., of so large an animal, with its covering coat of mail. It is curious that all these three genera are linked together by the same dental formula, and by the same sculptured teeth, which led to the adoption of the name *Glyptodon*,—the number and kind of teeth being the same in both jaws, viz.: $\frac{8 \cdot 8}{8 \cdot 8} = 32$,

whilst the formula in the *Armadillo* is $\frac{9 \cdot 9}{8 \cdot 8} = 34$. This group does not appear to have ever migrated from the regions of South America, although the *Megatherium* wandered more northwards; they formed therefore a local fauna of the highest interest, which is now only faintly represented by the *Armadillos*, including the genera *Dasyurus*, *Tatusia*, *Xeñurus*. M. Nodot considers, from the positions in which they are found, that they inhabited the Pampas, on the banks of rivers or of fresh-water lakes or pools, where they doubtless found an abundance of those plants which grow in damp localities and might have been easily scratched up by the slender yet rigid feet of these animals. It would be unwise to accept such large additions to so remarkable a group without strict scrutiny; but it is impossible to read the memoir of M. Nodot without the greatest gratification, and I may add that his views on classification, and on the plans of organization, are very ingenious. There appear to have been, he observes, three such plans,—the first, in which the body is equilibrated horizontally, the centre of gravity corresponding with the centre of the axis which passes through the length of the animal; the second, where the body is equilibrated vertically, the centre of gravity being behind the centre of the longitudinal axis and the third, in which the organization is sometimes conformable to the first type, and at other times to the second.

These views are illustrated in reference to the Mammalia by the different modes of progression of various animals, as, for example,

amongst the Carnivora, in which the Lion and the more humble Cat are well known to preserve in leaping a horizontal position, by extending forwards their necks and front limbs, and backwards their hinder legs and tail, and thus to maintain their equilibrium in that direction, which would be destroyed were the animal deprived of its tail, and amongst the Solipedes by the Horse, the neck, limbs, and tail of which are also thrown into a horizontal position in leaping. Well may M. Nodot observe that he cannot comprehend on what principle the English have adopted the barbarous practice of docking the tails of horses! In all such animals the tail is in great measure a counterpoise; but in those which are equilibrated vertically, it becomes one of the organs of support, as in the Marsupials, and still more strikingly in the fossil genera which have been the subject of M. Nodot's essay; and it is therefore curious that animals of so distinctive a type of organization should have been so restricted in distribution, both as regards space and time: and with this remark I shall close my notice of the valuable essay of M. Nodot, which I trust will attract the attention of some of our able palaeontologists.

In my last Address, I commented at some length on the description of numerous species of fossil Chelonia found in Switzerland, by MM. F. J. Pictet and Alois Humbert, and which are relics of the organic life of the Mollasse or Tertiary epoch. During the last year the same naturalists have been able to record the discovery of a new species, found in the forest of Lech, near Moirans, in the Department of Jura, the locality being in the French territory. A portion of the carapace, probably the dorsal, was observed projecting beyond the surface of the rock, by the peasants, who reported to the priest of a neighbouring village that it was the impression of the breast of a man; and his curiosity being excited, he had it carefully extracted, and presented it to M. Girod, the Vicar-general of the diocese of Saint-Claude. M. Pictet has named the fossil *Emys Etallonii*, after M. Etallon, Professor of the Lyceum of Saint-Claude, to whom he was indebted for the opportunity of examining and describing it. M. Etallon, a zealous geologist, had also explored and studied the highly-fossiliferous rocks which surround that city; and from the result of his investigations, M. Pictet concludes that the flat on which Moirans has been built belongs to the Upper division of the Jurassic Formation, or Portland Oolite section,—the rock in which the specimen was imbedded having all the characters which distinguish the rocks of that stage in the Department of the Jura and of the Ain. M. Pictet adds that the data are not sufficient to bring it into relation with the Chelonian Limestone of Soleure.

The dimensions of this fine specimen are as follow:—

| | | |
|---------------|---------------------|---------------------|
| Carapace.... | Length 1 ft. 7½ in. | Breadth 1 ft. 5 in. |
| Breastplate.. | „ 1 ft. 5½ in. | |

| | |
|---|--------|
| Depth and height between the upper face of the } carapace and lower face of the breastplate. } | 6½ in. |
|---|--------|

The carapace is nearly regularly oval—the anterior extremity being widely notched, and the posterior slightly acuminate: it is depressed as in the genus *Platemys*. The breastplate is solidly fixed to the carapace for about half its length, the free portions being both much narrowed, the anterior one subtruncated, and the posterior one acuminate.

M. Pictet describes in detail the bony pieces according to their respective positions, and as far as the condition of the specimen permits, and then, having made the most of his materials, discusses the affinities of the species. In respect to the genus, he considers that it belongs, without doubt, to the family of *Elodites* of Duméril and Bibron, but states that it is impossible to refer it more specially to any of the numerous genera of the family, as the generic characters of most of them are based on portions of the bony structure of the animal not preserved in the specimen, whilst, although clearly separated from some others by the solid manner in which the carapace and breastplate are joined to each other, there are not sufficient data for separating it from others. Under these circumstances M. Pictet thinks it prudent to retain for it the name of *Emys*, as originally defined by Alexander Brongniart, in 1803, when it embraced the whole family of *Elodites*. M. Pictet gives, however, the following diagnosis as a guide to palæontologists in estimating the value of the generic characters.

“Bony case flattened; breastplate extensively and firmly ankylosed with the carapace, without moveable pieces, perforated with two holes, narrow and subtruncated in front, terminated behind by a front not notched; a series of submarginal scales between the marginal scales and the sternal as well as the inguinal margins on each side; upper face of the marginal pieces very large, cut by the margino-costal impression very near its exterior edge.”

In respect to species, M. Pictet considers that it approaches nearest to *Pleurosternon latiscutatum*, Owen, known only from the carapace; but he points out several striking differences which separate it from that species, although he thinks it probable that both species belong to the same generic type, and that the discovery of the breastplate of Professor Owen's species might lead to its removal from the genus *Pleurosternon*. He explains also the many points of difference between the *Emys Etalloni* and the *E. Menkei*, Roemer, and *Platemys Mantelli*, Owen. It is therefore an interesting addition to the fauna of the Upper Oolite period.

In addition to the work I have just noticed of MM. Pictet and Humbert, M. Pictet has published during the year the 6th, 7th, 8th, and 9th parts of his contributions towards Swiss Palæontology,—being a series of Monographs of the Fossils of the Jura and of the Alps. A brief abstract of the species described, and of the localities in Switzerland and in other countries where they have been discovered, will explain in the simplest manner the value of these portions of a very important work; and it may be fairly said that the fact of finding so many mollusca common to England, France, and the limited localities of Perte du Rhône and Sainte Croix, is of even

higher interest than the discovery of new species. The 6th and 7th parts are devoted to Mollusca; and it will be noticed, in the abstract, that out of 25 species described, 3 only are new, the remaining 22 having been before named by preceding authors. This fact exhibits strongly the great caution with which MM. Pictet and Renevier have compared their specimens with the species of other countries, frequently with the specimens themselves, and proves that they have been free from that anxiety to make new species, which is too frequently a prevailing passion amongst paleontologists:—

“Terrain Aptien.”

Cardium Bellegardense, *Pict. & Renevier*.—Yellow Marl of Perte du Rhône.

Cardita fenestrata (*Forbes*), *D'Orbigny*.—Lower Greensand, Lower Neocomian, Perte du Rhône.

„ *Meriani*, *Pict. & Renevier*.—Yellow marl, Perte du Rhône.
Opis neocomiensis, *D'Orb.*—Yellow marl, Perte du Rhône.

„ *Mayori*, *Pict. & Renevier*.—Yellow marl, Perte du Rhône.

Astarte Buchii, *P. Roemer*.—Yellow Marl of Perte du Rhône, and of Sainte Croix. Lower Neocomian, France.

„ *obovata*, *Sowerby*.—Lower Greensand of Isle of Wight, Hard Grit of Perte du Rhône.

„ *laticosta*, *Desh.*—Middle Neocomian, Yellow Marl of Perte du Rhône.

„ *sinuata*, *D'Orb.*—Aptian Lamachella of Marolles, Yellow Marl of Perte du Rhône, Red bed of Wassy, and L. G. of Peasemarsch.

Crassatella Robinaldina, *D'Orb.*—Lower Neocomian, Hard Grits of Perte du Rhône, Yellow Marl of Sainte Croix.

Trigonia Dædalea, *Parkinson*.—Blackdown and Haldon (Dev.), Lower Greensand (*Forbes*), Neocomian, Yellow Marl, Perte du Rhône.

„ *nodosa*, *Sowerby*.—Lower Greensand, Hard Grits of Perte du Rhône.

„ *Archiaciana*, *D'Orb.*—*T. spinosa*, *Sowerby*.—Lower Greensand, Hard Grits of Perte du Rhône and Aptian Formation of Pont (Lac de Joux).

„ *ornata*, *D'Orb.*—Neocomian in France, abundant in Yellow Marl of Perte du Rhône and of Sainte Croix.

„ *caudata*, *Agassiz*.—Blue Marls, Neocomian, Neuchatel; Lower Neocomian, France; Lower Greensand, England; Yellow Marls of Perte du Rhône and Sainte Croix.

„ *aliformis*, *Parkinson*.—Gault, France; Lower Greensand, England; Hard Grits of Perte du Rhône, and probably in the Gault of these localities and of the Savoy Alps.

„ *carinata*, *Agassiz*.—Neocomian Marls of Hauterive, Neocomian, France; Lower Greensand, England; Yellow Marl of Sainte Croix.

„ *longa*, *Agassiz*.—Neocomian, Neuchatel; Lower Neocomian, France; Hard Grits and Yellow Marl of Perte du Rhône.

Trigonia Coquandiana, *D'Orb.*—Chloritic Chalk of Castellane, Lower Alps; Neocomian, Yellow Marl of Perte du Rhône.

Arca glabra, *Parkinson & Goldfuss.*—Greensand of Quedlimburgh and Aix-la-Chapelle, and, under various synonyms, Gault in France, and Lower Greensand, England, as also in Bohemia. Perte du Rhône.

„ *Robinaldina*, *D'Orb.*—Neocomian at Marolles, Lower Greensand of Isle of Wight, Yellow Marl of Perte du Rhône.

„ *Raulini*, *Leym. & D'Orb.*—Lower Neocomian, France; Lower Greensand, England; Yellow Marl of Perte du Rhône and of Sainte Croix and of the Presta. This species was first named by Leymerie as *Cucullaea Raulini*; and M. Pictet agrees with Edward Forbes in uniting to it *A. marullensis* and *A. neocomiensis* of *D'Orb.*

Nucula impressa, *Sowerby.*—Neocomian and Red Bed of Wassy, France, Lower Greensand, England; Yellow Marl of Perte du Rhône and of Sainte Croix. Several synonyms, such as *N. Cornuelina*, *N. planata*, *N. subobtusata*, are united to this species, as also *N. subrecurva*, *Phillips*, Speeton Clay.

Mytilus lanceolatus, *Sowerby.*—Neocomian, France; Lower Greensand, England; Yellow Marl, Perte du Rhône. Three species of *Sowerby* and two of *D'Orb.* are given as synonymy as, but do not materially affect the geological deductions. Yellow Marl of Perte du Rhône.

„ *sublineatus*, *D'Orb.*—Neocomian, Turonian, and Aptian, France; Lower Greensand, England; Hard Grits of Perte du Rhône; Yellow Marl of Sainte Croix, Gault of Perte du Rhône and of Savoy. This species absorbs *Modiola lineata*, *Sowerby*, *M. angusta*, *Roem.*, from the Hils conglomerate, *Mytilus lineatus*, *Sowerby*, *M. asper*, *Forbes*, &c.

Part 8, is devoted to the two orders Sauridia and Ophidia of the class Reptilia.

In the first, some bones of a head, collected at Mauremont by MM. De la Harpe and Caudin, are, after a careful scrutiny, identified with *Crocodylus Hastingsiæ* (Owen) from the freshwater Eocene beds of Hordwell Cliff,—a species which Professor Owen has shown to form a passage between the true Crocodiles and the Caimans. The left branch of a lower jaw, found in the breccia of Saint Loup by Professor Morlet, has all the generic characters of a true Lizard, but is insufficient for specific determination. It must have belonged to an individual of the same size as the common European species, *Lacerta agilis*. Two bony osselets of a cranial plate are referred by M. Pictet to the genus *Placosaurus*, Gervais, which was established upon one such plate. The French specimen was found resting on the cranium, which it protected, and was obtained from the calcareous Palæotherian Marls of Sainte Radefonde, near Apt; the Swiss specimens were found by Professor de Morlet in the breccia of Saint Loup.

The bony osselets, as described by Gervais, were irregularly hexagonal, mamillated on the surface by blunted tubercles having no

analogy with anything previously observed in reptiles. The characters of these osselets are quite in conformity with this description; they are irregularly hexagonal, protuberant, and covered with four concentric bands of smooth, rounded tubercles. As the diameter of these osselets is only about $\frac{14}{10}$ th of an inch, it is certainly a very curious fact that the *Placosaurus rugosus* of Gervais, founded upon the discovery in France of such minute osselets in direct contact with the cranium, of which, combined together, they formed a protecting plate or covering, should have been traced into Switzerland by means of the osselets alone, though in this case detached and isolated. If this identification be well-founded, it is only natural to expect that other vestiges of the *Placosaurus* may be hereafter discovered; and at all events such a fact is a striking illustration of the wisdom of the caution which Sir C. Lyell has given us, not to assume that certain animals have never lived because we have been unable to find their fossilized remains. Paleontology has done much to unravel the ancient natural history of the world, but it has yet much more to do. Of the other fossils described by M. Pietet, some were bones of a head, found by MM. Gaudin and De la Harpe at Mauremont, and which, though not without much difficulty, M. Pietet refers to a lost type of Saurians, closely related to the Iguanas. The reason of the difficulty in establishing this analogy is the striking resemblance of the inferior maxillary to that of an Ophidian; but, as the intermaxillary cannot be classed with Ophidian remains, the upper and lower maxillary evidently belonged to the same species; and as all the bones were so closely associated together, the inference seems well founded, that they belonged to a pleurodont iguana, of the size of the living iguanas, characterized by a flattened muzzle-shaped like a horse-shoe, the nostrils being large and widely-separated; by a series of small teeth on each pterygoid; by slender jaws armed with conical detached teeth, of which the anterior were very acute, thin, and slightly curved backwards. Having given these details, M. Pietet exhibits a wise reserve by refraining from giving a generic name to the animal until further discovery has provided more complete data. Four vertebræ, obtained by Professor Morlot in the breccia of Saint-Loup, are next noticed; two are comparatively large, and two smaller: the dimensions of the largest are, breadth, 1.02 in.; height, 1.06 in.; length, measured from one articulating surface to the other, half an inch nearly—and these in the smaller are similar in proportion, the height and breadth being nearly the same, viz. .55 of an inch. M. Pietet states that the large vertebræ, compared with those of *Python molurus*, appear to exhibit an almost perfect identity, excepting that the vertebræ of the living serpent are a little wider and shorter than those of the fossil; the differences between the fossil and the vertebræ of a *Python* figured by Professor Owen, are, however, greater. He then points out the analogies of the fossil with the recent genus *Eryx* and the fossil genus *Pteryx*, observing that he would have classed the small vertebræ, if alone, with *Pteryx rhombifer* of Owen, but that the larger vertebræ seem to have belonged to a more

robust serpent, and that on the whole he considers that, if all the vertebræ belong to the same genus, and that genus be *Paleryx*, the analogy of the genus is more with *Python* than with *Eryx*. At the same time there are, in the same deposit, smaller vertebræ, belonging probably to younger individuals of the same species, and which are more close in their resemblance to *Paleryx*. The discovery of this little nest of snakes in Switzerland, apparently the same as those of the Bracklesham Clay of England, is a most interesting fact as regards the distribution of fossils. Some Chelbrian remains found by MM. Gaudin and De la Harpe at Mauremont close the number: they appear to show the former existence of a small *Emys* and of a small Land Tortoise, scarcely determinable; and at the same time they have afforded materials for the restoration of the carapace, and partly of the breastplate, of a species which is assigned to the new genus and species *Dithyrosternon valdensc*, Pict. and Humb. It unites many of the characters of the Land Tortoises, associated with some of those of the *Emys*. The generic name implies that the shell has two moveable doors or valves. There are living genera which have the double valve, such as the *Cistudo*, where there is, however, no fixed portion of the breastplate between the valves, which simply move on a hinge; and the *Cinosternum*, in which the analogy as regards the two valves is complete, but in all other respects it fails.

Appended to the 9th part is a list of the Vertebrata of the Eocene Fauna found in the siderolite deposits of the Canton de Vaud.

Mammalia—Pachydermata.—1. *Palæotherium medium*, Cuv.—2.

Palæotherium curtum, Cuv.—3. *Plagiolophus minor*, Pomel.

4. *Palæotherium minus*, Cuv.—4. *Rhagatherium valdensc*, Pictet.

—5. *Hyracotherium siderolithicum*, Pictet.—6. *Oplotherium*.

—7. *Dichobune Campichii*, Pictet.—8. *Dichobune*, species near

to but a little larger than *D. cervina*, Owen; from isolated teeth.—9. *Dichobune*, smaller species, also from teeth alone.

Carnivora.—1. *Amphicyon*, species of the size of the *Conuar*;

from teeth alone.—2. *Cynodon*, probably new species of the

size of *C. lacustris*, Gervais, from teeth alone.—3. Indeterminable, of the size of the *Ocelot*.

Cheiroptera.—1. *Vespertilio Morloti*, Pictet.

Rodentia.—1. *Theridomys siderolithicus*, Pictet.—2. *Sciurus*.—

3. *Spermophytus*?

Reptilia—Sauridia.—1. *Crocodylus Hastingsæ*, Owen.—2. *Lacerta*.

—3. *Placosaurus rugosus*, Gervais.—4. Saurian of extinct species, probably belonging to the group of *Iguanas*.

Ophidia.—1. *Python*.—2. *Python* or *Paleryx*.

Chelonina.—1. *Dithyrosternon Valdense*, Pictet & Humbert.—2.

Cinixys?—3. *Emys*, large species.—4. *Emys*, small species.

—5. *Testudo*, small species.

Most of these fossils were obtained by the labours of either MM. Gaudin and De la Harpe, or of Professor De Morlot; and as the illustrations, both of them and of the Mollusca previously noticed, are extremely well drawn and lithographed, the work may be justly

considered highly creditable to the palæontologists of Switzerland and to Geneva, of the Academy of which city M. Pictet is a Professor.

I have already had occasion to notice the varied labours of Herman Von Meyer, whilst stating to you the grounds upon which the Council had awarded to him the Wollaston Medal; but it is right that I should briefly notice in more detail the later numbers of the 'Palæontographia,' a work which is the joint production of Dunker and Von Meyer. In the July number, the history of the discovery of reptilian remains is briefly but succinctly stated, from the time when the *Botryosaurus* of the Zechstein formation, a genus established by Von Meyer, was deemed the oldest or first reptile form of the ancient world, to the discovery, in 1847, by Von Dechen of remains which were distinguished from the fish-remains of the Coal Formation of Lebach, in Rhenish Prussia, and were rightly assumed to belong to Reptilia. The relics of the past which first attracted attention were Coprolites of a finger's length; but Von Dechen soon set the peasantry to search for all kinds of fossil remains, and five nodules containing reptilian relics were brought to light, from which Goldfuss established the genus *Archegosaurus*. Before, however, this positive determination of the existence of reptiles at so remote an epoch as the Coal formation, several geologists and palæontologists had suspected their existence; but either the actual age of the deposits, or the true nature of the fossils remained uncertain. The nascent expectation, however, that Reptilian remains would be found was a proof that old prejudices were beginning to give way; whilst their original depth may be understood from the fact cited by Von Meyer, that the first specimen of the *Archegosaurus* was found in 1777, and was long afterwards described as the head of a fish by Agassiz, who named this very specimen, even then the only one known, *Pygopterus Lucius*, evidently, therefore, considering it a fish: so sure is any long-admitted theory to interfere with the due appreciation of truth when it comes in an unexpected form. The imaginary boundary once passed, other Reptilian remains soon flowed in from the Coal formation. In 1848 Von Meyer proved that the cranium upon which Goldfuss had established his *Scelerocephalus Hauseri* belonged to a reptile, and not to a fish. In 1849, Jordan established a second species of *Archegosaurus*, *A. latirostris*, also from Lebach, where the first species, *A. Decheni* had been discovered. In 1853, Professors Wyman and Owen named some Reptilian remains found in Nova Scotia *Dendrorepeton acadianum*; another specimen, from the coal of the neighbourhood of Glasgow, Prof. Owen termed *Parabatrachus Colei*; and in 1854, Nova Scotia supplied him with the data for establishing his *Baphetes planticeps*. All these reptiles belonged to the remarkable family of *Labyrinthodonta*; and Von Meyer observes that the *Telerpeton elgmense* of Mantel, though from the Upper Devonian, may be considered as belonging to the same geological period,—an opinion in harmony with the views of the present leading Irish geologists, who consider the Old Red Sandstone to be simply the base of the Carboniferous deposits; and I may add that I have repeatedly urged the

probability of the lowest portion of the Devonian system belonging to the Silurian, and the upper to the Carboniferous.

M. Von Meyer then gives a detailed description of the genus *Archegosaurus*; and nothing can more strikingly exhibit the extensive range of the genus at the Carboniferous epoch than the fact that 271 specimens have passed under the inspection of M. Von Meyer, in addition to two specimens from England, and three others described by Goldfuss, Burmeister, or Jäger, which had not been personally examined by him: of these he has figured 102, and, having ascertained, from careful examination and comparison, that the embryonic condition and stages of growth of the animal may be recognized, he unites *A. medius* and *A. minor* of Goldfuss with *A. Decheni*,—an arrangement which reduces the genus to two species, *A. Decheni*, and *A. latirostris*. A short notice of *Apateon pedestris* and of *Sclerocephalus Hauseri* closes this section of the work,—both being of the Labyrinthodont type, but yet distinct from the genus *Archegosaurus*: the latter is from shale resting upon beds of coal; the former (*Apateon*) from the coal-shale of Münster-Appel, being the first specimen which carried the epoch of reptilian life back to the Carboniferous formation.

The other section of the work of Von Meyer, published during the last year, is devoted to the plants of the Chalk Formation of the Hartz, from Blaukenburg and Quedlinburg. The interesting character of the Chalk flora, from the many points of approximation to the existing flora which it affords, is well known. M. Von Meyer reviews the works of his predecessors, and by description and illustration endeavours to reform anything which may have been defective in them. From the genus *Crednera*, Zenker, so remarkable for its hazel-like leaves, 11 species have been transferred to the genus *Ettinghausenia*, of Stiehler, which resembles the *Cistidæ*: these were all from the Blankenburg deposits. Those of the Long Mountain near Quedlinburg, have yielded, of Ferns, the species *Weichselia Ludovici*, Stiehler; of Pandaneæ, *Pandanus Simildæ*, Stiehler; of Cycadeæ, *Pterophyllum Ernestinæ*, Stiehler: and it may be added that the chemical examination of other specimens detected the former presence of organic vegetable bodies by the quantity, though small, of carbonaceous matter they contain. A description of the flora of the younger Brown-coal, by M. R. Ludwig, adds value to the work of Von Meyer, and displays, as usual, a still nearer approximation to the existing flora, as such names as *Vaucheria*, *Conserva*, *Potamogeton*, *Pinus*, *Taxus*, *Myrica*, *Arundo*, *Lobelia*, *Magnolia*, &c. &c. testify,—even our very recent discovery, *Victoria regina*, finding its representative in the genus *Holopteleura* of Ludwig, to which he gives the specific name *Victoria*, from its near approach to the genus of that name.

It cannot be doubted that the brief notice I have given of a portion of a great work will add weight to what I have already stated in pointing out to you the great merits and services of those distinguished paleontologists, Von Meyer and Dunker. Many more names might be cited as a proof of the universal spread of enthu-

siasm about the history of the past world, such as Weber, Von Hauer, Von Hagenow, Schnur, in addition to those which have long become household words amongst men of science.

Of the latter, the distinguished countryman of Dumont, M. de Koninek, is still earnest in his endeavours to perfect the fauna of the Carboniferous epoch. In a paper addressed to the Belgian Academy, he notices the distribution of some of the Carboniferous fossils, stating that he had already determined the existence of more than 600 species. These he has grouped in three sections,—the first belonging to the Coal-formation, properly so called, the second to the limestone of Visé, and the third to the limestone of Tournay. In Belgium, the fossils of the first section are peculiar to the strata in which they are found; but in the other two groups some are found common to both, whilst others are characteristic of either one or the other limestone. M. de Koninek adds that the same facts may be observed in both England and Russia,—the fossils of the neighbourhood of Bristol and of Moscow being the same as those of the limestone of Tournay, whilst those of Newcastle, Glasgow, and Gosatschi-dakshi in the Oural Chain are identical with those of Visé. Whilst, indeed, he observes, this existence of the same species at widely-separated localities is one of the great palæontological facts, it is not less curious to observe how localized some species are, though belonging to the same epoch (a fact, I may add, equally observed in recent natural history), as for example, *Spirifer striatus*, *S. rotundatus*, and *S. cuspidatus*, abundant in the Carboniferous limestone of the neighbourhood of Dublin, are not found at Hook Head, county of Wexford; and in the same manner, the limestone of Tournay has never furnished these *Spirifers*, though they are abundant in that of Dinant, which belongs to the other section. As an interesting notice of new discovery, he states that M. Dupont, to whom he was indebted for the latter remark, has also enabled him to state that 130 species of Mollusca are found in connection with the *Spirifers*, of which about 30 are new, including some magnificent specimens of *Cardiomorpha*, *Avicula*, and *Aviculopecten*, which M. de Koninek proposes to describe very shortly, as an addition to a fauna already so rich.

Before closing this brief notice of the labours of one of our most active foreign friends, I may observe that he submitted to the British Association at Dublin last year his description of a third species of the genus *Davidsonia*. In the generic name he had testified his recognition of the merits of one of our most able palæontologists, and in the specific he has borne testimony to those of another of our most able naturalist members, by adopting the term *Woodwardiana*. This Devonian genus he places in the family of Productidæ, from the existence of spines along the hinge, which separates it from the Strophomenidæ, whilst he does not think there is any reason for establishing a specific family under the appellation of Davidsonidæ. Every peculiar Devonian type must be considered an advantage gained, by those who maintain the independence of that formation.

It is right to observe that, whilst our knowledge of the fauna of the ancient world is daily increasing, new information respecting

that fauna which is so closely connected with our own existence, and has been so long studied, is constantly flowing in upon us. Dr. H. A. Philippi, Professor of Natural History at the University of Santiago, in Chili, for example, describes a new species of the genus *Thysanopus* under the name *T. australis*, which he discovered on examining the stomach of a fish. He speaks of the discovery as remarkable, since the species already known to him was from the European seas: the editor, however, of Wiegmann's Archiv adds to this remark, that Brandt had enumerated 7 species of the genus, in Von Middendorff's Voyage. In either case the wide distribution of a genus comprising such minute species, eight lines in length, is a fact of much interest. Of another Crustacean of the order Stomatopoda, he forms a new genus *Hoplites*, and gives it the specific name *longirostris*. It was found in the Atlantic ocean, in 25° N. lat. and 22° 50' West long. *Leucifer Zybrantsii*, Ph. is a new crustacean found in the same position by Captain Peter Zybrants, who commanded the ship which conveyed Dr. Philippi to Chili. *Alima valdiviana*, and *A. vetula* are two new species of a genus not before traced to the American coast, and found in the harbour of Valdivia. The new genus *Euacanthus* is also established from a minute crustacean of the order Stomatopoda, and the new species *Megalopa valdiviana* from another three lines long. Of this latter, Dr. Philippi remarks with great justice, that even though his observations may not prove sufficient to determine the question whether *Megalopa* is a full-grown and perfect animal, or merely an immature condition of some other genus, the existence of that form of crustacean in the Chilian seas is not less a fact of great interest. Were I to go through the 12 new Echinodermata described by Dr. Edward Grube of Breslau, or follow Dr. Troschel in his analysis of the progress of discovery in natural history both in America and Europe, I should have no difficulty in establishing the fact that the time is still far distant when it will be possible to study the system of nature as one great whole, combining the extinct and the living: and so this fact, far from discouraging, ought to exercise upon every naturalist the most powerful and stimulatory influence; for who can tell what will be the ultimate result of man's researches and of man's unprejudiced reasonings upon them?

Physical Geology.—As the physical condition of the crust of the earth has been not only affected by the action of external force, including all aqueous and aerial agencies, but also by the action of internal forces, it becomes important to study whatever is calculated to throw light upon the processes of nature which, though unseen, are too often felt to be going on under our feet. Of all our members, Dr. Daubeny has most distinguished himself by his able advocacy of the chemical theory of volcanos; and although that theory may not be considered sufficient to explain all the phenomena, it is impossible to doubt that chemical action must be going on extensively in the interior of the earth, and that it is of the utmost importance to study the nature of that action. The paper by Dr. Daubeny on the Evolution of Ammonia from Volcanos, deserves therefore especial

consideration, as it is evident that the volcano must be considered the discharging flue of the subterranean laboratory, and therefore the place where its gaseous products ought to be traced in their passage outwards. That ammoniacal compounds are found in the vicinity of volcanic vents is well known; but MM. Bischoff and Bunsen have endeavoured to prove that the production of ammonia is due to chemical action on the surface, and not within the crust of the earth, as, for example, in the celebrated hypothesis, that the hot lava, whilst overflowing the herbage, so far promotes its decomposition, as to set free its nitrogen, which uniting with the muriatic acid of the lava, became sublimed as sal-ammoniac. This theory, though ingenious, is shown by Dr. Daubeny to be inapplicable to many volcanic districts, in which, though the herbage is far too scanty to supply a sufficiency of nitrogen, the sal-ammoniac is not less in quantity; he therefore adopts, as in his opinion more probable, the theory of the formation of ammonia within the crust of the earth, and adduces, in support of his explanation, the affinity which certain metals are known to possess. For example, Wöhler and Rose have proved the existence of a compound of titanium with nitrogen; and Wöhler and Ste.-Claire Deville have shown that titanium absorbs nitrogen even from the air, and that heated titanous acid, when brought into contact with nitrogen, leads to the production of a nitride of titanium with so intense a chemical reaction as to generate light and heat, nitrogen in this case, instead of oxygen, acting as the supporter of combustion. Dr. Daubeny also alludes to the recently discovered fact, to which I shall again refer, that boron, like titanium, has the property of combining directly with the nitrogen of the air, and that the compound thus formed possesses the property of evolving ammonia under the influence of the alkaline hydrates. Dr. Daubeny further observes that we cannot fairly conclude, from the difficulty hitherto experienced in producing a direct combination of nitrogen and hydrogen, that such a combination would be impossible under the different circumstances of pressure, heat, &c. which may be expected within the crust of the earth: in fact, he considers that such circumstances might even be sufficient to induce the combination of hydrogen and nitrogen, and thus produce ammonia directly, although it has not been possible to do so in the laboratory of the chemist. Titanium is present in most volcanos, though Dr. Daubeny admits that it is not sufficiently abundant to account for the large quantity of sal ammoniac known to occur, and, I will add, for the continued production of it, unless, indeed, it be assumed that the titanium discovered outside the volcanic vent, and freed from the nitrogen with which it may have been combined, is only a small portion of that which has passed through the chemical decomposition, and still remains below the crust. Such a conclusion would not be unreasonable, as it is certainly quite consistent with sound speculation to deduce what is passing out of sight from that which can be actually observed. Boracic acid, however, is sufficiently abundant in many volcanos to account for the production of any amount of ammonia; and it only remains in those cases to determine whether the chemical reactions which have led to the

production of ammonia took place actually within the volcanic crater, or during the process of eruption,—assuming in the first instance, that the combination of boron, titanium, or any other metal with nitrogen had at least been effected in the volcanic laboratory.

The paper by Mr. Robert Warington, F.C.S., read so far back as 1854, at the Liverpool meeting of the British Association, and published in the *Edinburgh New Philosophical Journal*, April 1855, is valuable, as it shows the actual circumstances under which both boracic acid and ammonia may be found. Mr. Warington founds his remarks on information from a friend who visited the island of Vulcano, twelve miles north of Sicily. The volcanic mountain is estimated to be 2000 feet in height, and its crater is about 700 feet deep. The area at the bottom, about 10 acres in extent, is paved, as it were, with small loose fragments of limestone; and the ground is so hot as rapidly to destroy the leather of the shoes. A thermometer thrust between the stones indicated a temperature between 250° and 500° ; so that the conditions of the locality were peculiarly favourable for the study of the phenomena under consideration, as it is evident that there was nothing extraneous to interfere with the results. On looking down on the area, it appeared covered with a substance like finely-drifted snow, which was found, on examination, to consist of crystallized boracic acid. This incrustation, about an inch thick, being dug through with a pickaxe, a mass of red-hot fused lava, similar in appearance to the slag of a glass-house, spumed up, and was found to consist of fused saline matters forming a coherent mass of volcanic debris. “When the ground covered with boracic acid is dug down for about eight inches, a red-hot mass of sal-ammoniac is always found,” as also sulphur. Now this is not a temporary phenomenon, as the boracic acid is constantly renewed when removed, and has become, together with sal-ammoniac and sulphur, a regular source of income to the proprietors, to whom it yields about £1000 per annum,—sulphur being obtained by fusing the stone of which the sides of the volcano are composed, sal-ammoniac from the lixiviation of the scoria or lava, and boracic acid, either at once from the surface, or by receiving the sublimed acid in open barrels filled with broom-twigs or other plants, placed there for its reception.

It will be observed from these observations, as Mr. Warington states, that the sal-ammoniac sent to him was obtained by the lixiviation of the fused mass; and its exact condition, therefore, in that mass he had no means of determining. On the boracic acid, however, which came to him as collected, he was enabled to experiment. The boracic acid having been boiled in diluted muriatic acid, the solution was subsequently decanted from the undissolved portion. This again was boiled in a weak solution of caustic potash, without yielding any trace of ammonia, but the residue being washed with distilled water, dried and fused in a tube of hard glass with caustic potash, gave strong evidence of the formation and liberation of ammonia. From these experiments, therefore, Mr. Warington concludes that the reactions are similar in character to those effected by Balmain in 1842, and by Wöhler. In them the nitride of boron was first ob-

tained by heating borax and ferrocyanide of potassium (both anhydrous) to a dull red heat in a crucible; and this, being fused with caustic potash, gave out ammonia copiously, or, if heated in a current of steam to a moderate red heat, was entirely converted into boracic acid and ammonia. These experiments unquestionably explain the simultaneous presence of boracic acid and ammonia in volcanic craters, considering that nitride of boron had been previously formed in the interior of the volcanic vent, and then brought into contact with either alkaline bases under a high temperature, or with heated steam. The same may be said in respect to the reactions consequent on the formation of nitride of titanium, or of the nitride of any other metal within the volcanic vent. All these reactions are natural in their way, consistent with the circumstances of volcanic action, and confirmatory of Dr. Daubeny's views.

Admitting, then, the reasonableness of Dr. Daubeny's views, and those of Mr. Warrington, as to the production of the ammoniacal compounds so generally found in connexion with volcanos, the source from which the nitrogen, presumed to be of internal origin, has proceeded, can only be conjectured. From the smoke-vents of lava-streams, as well as from those of the craters of volcanos, atmospheric air was evolved, in combination with other gaseous products; but it was often found poorer in oxygen, or, in other words, richer in nitrogen, than in a normal state, according to Deville,—whilst Pallei states (as quoted in the *Jahresbericht der Chemie* of Liebig and Kopp) that the gas collected in the Lago di Naftia, in Sicily, on the 5th October, contained 17·4 volumes of oxygen, and 82·6 of nitrogen, and on the 22nd October, 5·0 of carbonic acid, 15·8 of oxygen, and 79·2 of nitrogen. From the same Journal we learn that C. Schmidt had examined the boracic-acid vents of Monte Cerboli in Tuscany. According to his researches, the boracic acid cannot be found in the mixed vapour and gas which issues from the vent itself, but in the shining mud which floats over its mouth, and there in combination with carbonic acid, ammonia, and a small quantity of sulphuretted hydrogen. In fact, salts of ammonia abound in the dark-grey mud of these mud-lagoons; and after, in the refining process, the greater portion of the boracic acid has been removed by crystallization, the residue, obtained from the mother-liquor when condensed by evaporation, yielded on analysis the following results—the first from a specimen obtained by M. Abich, and the second from one collected by M. Schmidt himself:—

| | NH ₄ O, SO ₃ | Mg O, SO ₃ | CaO, SO ₃ | KO, SO ₃ | NaO, SO ₃ | NH ₃ Cl | Fe ₂ O ₃ } NH ₄ O, Al ₂ O ₃ } | | | HO ₃ | Total. |
|-------------|------------------------------------|-----------------------|----------------------|---------------------|----------------------|--------------------|---|-------|-------|-----------------|--------|
| Abich's Sp. | 5·328 | 4·116 | 0·160 | 1·086 | 0·266 | 0·178 | 0·139 | 0·019 | 1·754 | 13·066 | in 100 |
| Schmidt's | 9·667 | 1·843 | 0·102 | 0·419 | 0·515 | 0·109 | 0·614 | 0·011 | 3·094 | 16·373 | „ „ |

with a trace of oxide of manganese and of silicon.

Here the co-existence of ammoniacal salts and of boracic acid is again manifest; and it may be fairly assumed that they are the results of the same chemical reaction. In a letter to M. Elie de Beaumont, M. Bornemann mentions a case where the nitrogen is given out in a free

state, and where it has apparently not gone through the first step of combination with boron, which appears to be essential for the production of ammonia.

In this letter he notices the gaseous and aqueous emanations in Sardinia, as supplementary to the labours of M. Deville. These he considers as the last exhibitions of volcanic action in Sardinia, where, although there are many remains of ancient volcanos, there are no true volcanic vents of gaseous matter,—the emanations proceeding from mineral waters or thermal springs, all of which are situated in close proximity to the ancient volcanic districts. These emanations are rich in carbonic acid and azote, and contain also some free oxygen. M. Bornemann concludes his notice by eulogizing the Geological Map, and work on Sardinia, of General Albert de la Marmora.

Perhaps no one has devoted more attention than M. Ch. Sainte-Claire Deville to the gaseous products of volcanic vents. In a former memoir he laid down the proposition that the physical and chemical properties of the gas-vents of any volcano are influenced, on the one hand, by the distance of the observed orifice from the initial point of emission, and on the other by the interval of time between the moment of observation and the initial moment of eruption. As this proposition implies variations in the nature of the gaseous emanations, corresponding to variations in their position and the time of emission, M. Deville has endeavoured to illustrate his position by a study of the chemistry and stratigraphy of the subject, so as to test in the laboratory the reactions which have taken place between the elementary substances recognized as existing in volcanic districts, and thereby to explain the observed modifications in the halogene sulphureous or carbonic emanations. These emanations he divides into two groups, according as the *motive substance*, or substance which gives rise to the chemical reactions, is either hydrogen or a haloid body such as chlorine or fluorine; and M. Deville points out the *antagonism* between these two classes of emanations: for, whilst chlorine and its congeners decompose water by absorbing its hydrogen, its oxygen being fixed by the alkaline metal which accompanies them, sulphur and carbon, when emitted in combination with hydrogen, produce a contrary effect, by giving out the hydrogen and reconstituting water at the expense of the oxygen of the air,—the equilibrium of the forces manifested in natural phenomena being thus preserved.

Along the course of a lava-stream it is also seen, in respect to the halogene and sulphureous emanations—and in this case M. Deville observed no other gases—that their transformations, explained on chemical principles, are influenced by the position of the gaseous vents, the characters of which vary according to their distance from the focus of eruption, and to the time which has elapsed since its commencement,—those two coordinates of time and space representing the variations of temperature under the influence of which, and by the instrumentality of the primary elements or constituents of the gaseous emanations and of the accessory elements either derived

from the rocks through which they pass or from the air, the various products which M. Deville enumerates have been formed. Each order of emanation has therefore its peculiar products, which are, in M. Deville's opinion, merely modifications, under the influence of variable physical and chemical causes, of the same compounds, derived from the incandescent materials of the volcanic eruption.

The difficulty is greater when the inquiry is directed, not merely to the gaseous vents of the lava-stream, but to the vents of the volcanic cone itself, assumed, as they are, to communicate by a transverse fissure with the internal focus, as the variations then observed depend on causes similar to those which have produced in the interior of a vein the successive deposition of different substances. Generalizing the phenomena, an analogy is recognized between the gaseous emanations which succeed each other in a volcano during the course of a single eruption, and those which, in the series of ages of our globe, have predominated at each successive epoch. As, for example, when at the commencement of an eruption chlorine and fluorine are the gaseous emanations which proceed from the orifices of the lava, whilst phosphate of lime and oxidulated iron are fixed in the rock, can we not perceive an analogy between the workings of existing volcanic forces and those phenomena of emanation which under the influence of the same agents, chlorine and fluorine, have enriched the most ancient consolidated rocks with tourmaline, phosphate of lime, oxide of tin, or, in a word, with that galaxy of bodies, intimately connected one with another, which has been figuratively named the *penumbra of granite*?

M. Deville then endeavours to explain how the gaseous vents are distributed over the volcanic mass, and to prove that their positions can be referred to the great stratigraphical accidents of the country.

The effect of an eruption is to determine, on the cone, fissures the direction of which prolonged would sensibly pass through the centre of the crater; and in a volcano in a state of eruption, two kinds of operating agencies may be recognized; the one eccentric in connexion with the fissures produced by the eruption, or with the orifices of gaseous vents; the other central, at the summit of the volcano, or common centre to which all the fissures converge,—the first generally acting only during the duration of the eruption, whilst the latter acts variably but constantly. The object of M. Deville is to define precisely the functions performed by each, either in a period of tranquillity, or during the height of an eruption, or at the moment when the intensity of volcanic action retires from the fissures to the normal focus, and thus, by establishing the mutual connexion of one with the other, to obtain the means of predicting the effects to be expected from observations made during any particular form of eruption; as for example, in respect to the eruption of Vesuvius in 1856, M. Deville, from the facts he had observed, did not hesitate to announce the probability of a series of small eruptions from the summit of the volcano,—a prediction which was fully verified.

But it was yet to be determined whether the fissures, which perform so important an office in volcanic eruptions, are merely acci-

dental and ephenental, or are intimately connected with those powerful mechanical forces which have at various epochs broken the crust of the earth, and left everywhere ineffaceable marks of their action behind them; and in investigating this question, M. Deville determined, from numerous observed facts, that the planes of fissure penetrate the volcanic mass so deeply, and with such a permanency of direction, as to preserve a remarkable regularity, at successive great explosions of the eruptive forces.

M. Leopold von Buch had pointed out the tendency of volcanic vents to arrange themselves in lines corresponding to the direction of volcanic chains, or radiating from central volcanos; and M. Deville modifies the expression of this view, by stating that a central volcano always occupies a peculiar point, fixed by the intersection of two or more volcanic lines, and supports his opinion not only by the facts he had observed at several volcanic chains, but also by the theory of M. Elie de Beaumont, in itself directed towards a different object, and shows that, on the principle of a pentagonal network of lines of elevation, Etna occupies one of the summits of a rectangular spherical triangle, one side of which passes through Teneriffe, and the other connects Etna with the Eolian Islands, Vesuvius, and Mauna-Loa of the Sandwich Islands; so that the geographical distribution of volcanos, the manner in which the mechanical effects of earthquakes are exhibited, and the chemical peculiarities of gaseous emanations seem to correspond with general laws of stratification. M. Deville also points out—and the fact is important in reference to the general question—that in the Isle of Teneriffe each of the lines which cut the Peak of Teyde is characterized by the appearance of a peculiar kind of volcanic rock.

By this class of investigations the special phenomena of volcanos, which can be still observed, are put into relation with the more general phenomena of elevation by which the stratification of the earth's crust has been modified, and which can now no longer be observed; and a step is therefore made towards a physical history of the earth. M. Deville has continued through the year to detail the results of his researches, all of which have a bearing more or less in conformity with his theoretical views. In gas-vents, where there is neither vapour of water nor acids, the oxygen and azote proceeding from them are mixed in proportions not sensibly different from those of normal air,—whereas from vents which exhibit traces of vapour of water, or hydrochloric or sulphurous acid, the proportion of azoto is in excess of that of oxygen; and this is the same, whether the vent is from a stream of lava or from a volcanic crater. In illustration, M. Deville gives the following results of the examination by himself and M. Felix Leblanc, of the gaseous emanations of Vesuvius and Vulcano, after abstracting from them the hydrochloric acid and the vapour of water:—

| | Vesuvius. | | | Vents with flame. | | Valcano. | |
|---|-----------|-------|-----------|-------------------|-------|----------------|------|
| | 1. | 2. | 3. | 1. | 2. | Without flame. | |
| Sulphuric Acid | 2.6 | 2.4 | 0.3..... | 39.1 | 27.5 | | 69 6 |
| Oxygen | 18.7 | 19.7 | 17.6..... | 5.8 | 14.0 | | 5.5 |
| Nitrogen | 78.7 | 77.9 | 82.1..... | 55.1 | 58.5 | | 21.9 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | | |
| Oxygen in 100 parts of the combined oxygen & nitrogen | 19.3 | 20.2 | 17.6..... | 9.6 | 19.1 | | 18.8 |

Now, as the normal proportions of oxygen and nitrogen are 20 or 21 O. and 80 or 79 N, it is evident that in few instances were the true proportions of normal air preserved, whilst in several the proportion of nitrogen was greatly in excess. The fact, therefore, that nitrogen appears in a portion of the gaseous emanations of volcanos, cannot be doubted; but, as oxygen appears contemporaneously with it, the question still remains to be answered, whether the atmospheric air, of which it appears to have once formed a part, has only been sucked into the mouth of the crater, or whether it has been carried, either in combination with water, or in any other state, deep into the interior of the earth or down to the very focus of volcanic action. It is somewhat remarkable, indeed, that the gases of Vulcano, which are accompanied with vapour, and contain air so poor in oxygen and so rich in nitrogen, are those which, as stated by Mr. Warrington, deposit sulphur, boracic acid, and muriate and hydriodate of ammonia, exhibiting therefore so great an excess of nitrogen as almost to demonstrate that the reactions which gave rise to the production of ammonia and the collection of an excess of nitrogen must have been internal. The gas proceeding from the spring of Santa Venerina on the flank of Etna yields nitrogen entirely free from oxygen; and M. Deville states that he looks upon volcanos as vast chimneys into which, by means of the lateral fissures connected with them, the atmosphere is sucked in, and there freed by combustion of all or part of its oxygen, and that the emanations from vents in a plane of eruption exhibit a combustion less and less energetic as it recedes from the centre of activity, which corresponds with the view already enunciated,—namely, that in any one vent the intensity of action will diminish in proportion to the time elapsed since the commencement of the eruption, but in many contemporaneous vents the intensity will be in proportion to their distance from the focus of eruption or main crater. This notice of the labours of M. Deville will, it is trusted, convey an adequate idea of their importance, either as bearing upon the subject brought under our notice by Dr. Daubeny, or upon the still higher generalizations of physical geology. The operations of the volcanic laboratory may be investigated in the laboratory of the chemist, and, when once satisfactorily explained, afford a clue to the investigation of phenomena, of which the mode of production has long since been veiled from direct observation.

M. J. Durocher has directed his attention to another form of this interesting inquiry, and has studied with much attention the chemical

constitution of igneous rocks for more than twelve years. Researches of this kind illustrate the manner in which the simple elements of the crust of the earth have been so combined as to produce rocks of considerable apparent, but little real difference. It is for this purpose that M. Durocher investigates with great care the atomic properties of the oxygen of the silica and of the bases of these *magmas*, the solidification of which has produced the igneous rocks. In the hornblende series, the ratio of the oxygen of the silica to that of the bases exceeds 3 to 1, except in trachytic lavas and phonolites; so that, on the *magma* solidifying, it is resolved entirely into a crystalline mass, and the silica which is in excess becomes free in the form of quartz. In granite, the proportion between the oxygen of the alumina and that of the alkaline and alkali-earthly bases is, on the average, 3.7 to 1; and, as there is more alumina than is necessary to produce merely a felspathic mineral, the excess of alumina contributes to the production of mica. In normal granite there is about 35 per cent. of quartz, and 40 to 45 of felspar which has absorbed $\frac{3}{4}$ ths of the alumina, the remaining $\frac{1}{4}$ th serving to produce the mica in the proportion of 20 to 35 per cent.; and M. Durocher observes that the *same magma*, on solidifying, may, through a variation of circumstances, take the form of a granite, sometimes more rich in felspar, and sometimes in mica and quartz. Where the oxygen of the alumina in the erupted mass was nearly three times that of the protoxides, very little mica was found, and a pegmatite more or less rich in felspar was the result. It is easy indeed to imagine how readily the variations of physical circumstances sometimes consequent on tranquillity, sometimes on disturbance, must tend to alter the distribution of the mineral elements, and thus to produce, on solidification, different results; it is curious also to observe how in the long series of events the alumina becomes proportionally diminished, and gives rise to newer forms of igneous rocks. M. Durocher states that, in the felspathic rocks of the tertiary and recent epochs, the oxygen of the alumina bears a proportion to that of the alkaline and earthy-alkaline bases of less than 3 to 1; so that all the *magma* cannot be changed into felspar, and part continues in the state of a paste, or forms other minerals less aluminous than felspar. These and many other variations in the resulting rocks produced by the solidification of the *magma* are described by M. Durocher, and the general atomic relations shown by tables; and this is the interesting conclusion of one of his papers, "the present essay has exhibited the physical, chemical, and geogenic relations which connect together the igneous rocks, however varied in their aspect. The clearness with which these relations have been unravelled confirms the proposition I have laid down, that all igneous rocks have been derived from *two mineral beds or layers*, situated below the crust of the earth—one characterized by its richness in silica, and the other, though poorer in silica and in alkalis, containing a very much larger proportion of alkaline earths and oxide of iron, and at the same time distinguished by very different atomic proportions. I have thus successively thrown light upon the mutual relations of eruptive products.

on the generation of the minerals they contain, on the history of their emission, which I have simplified, and on their natural classification."

According to M. Durocher's view, silicium performs the same office in the mineral kingdom as carbon performs in the organic world, acting as a polybasic acid, and uniting with the oxides in very different proportions, so as to give rise to a great variety of combinations; and hence that the minerals which constitute rocks must depend principally upon the materials brought into chemical action. After comparing his own chemical analyses with those recorded in the works of other writers, M. Durocher concludes that the granites, eurites or felspathic and quartziferous porphyries, trachytes, phonolites, pearlstones, obsidians, pumice, and lavas, rich in vitreous felspar, were produced from the first of his *magmas*, whilst diorites, ophites, melaphyres, cuphotides, hyperites, traps, basalts, and augitic lavas proceeded from the second.

M. Durocher also states that, if the different varieties of one type of rock, such as granite, be examined, there will be often found a greater difference in their elementary composition than in that of different species proceeding from the same magma; as, for example, those between granite and a trachyte or a pumice, and he then arranges in a tabular form the several species supposed to proceed from each magma; remarking that the differences are equally due to the conditions of pressure, temperature, and cooling as to mere elementary composition, and he adds that the magmas which have produced igneous rocks are similar to metallic baths containing in a state of fusion various metals, which on cooling give rise to alloys differing from each other according to the circumstances of solidification. He adds that, where the two layers or magmas are in contact, hybrid products are formed, or rocks which have petrographic and geological affinities, sometimes approximating them to the true rocks of one magma, sometimes to those of the other. The upper zone, rich in silica, and poor in earthy bases and in oxide of iron, has the least density, and its specific gravity differs from that of the lower as much as oil in this respect differs from water,—a circumstance to which is due the permanent separation of the two magmas. The solid crust, therefore, of the globe rests, in M. Durocher's opinion, upon a fluid zone composed of two distinct layers: the upper, which is the most refractory, being only semifluid or pasty; the second much more fluid and dense. It is to this second magma, so rich in oxide of iron, that he ascribes the eruptions of oxidulous iron which have appeared in the manner of igneous rocks in Italy, the Oural Mountains, and Scandinavia, being connected with hornblendic or augitic rocks; and in the upper bed he considers that light or volatile bodies would be concentrated, such as alkaline metals, fluor, boron, &c.: it is indeed amongst granite rocks proceeding from this layer that the fluor-silicates, boro-silicates, as mica, topaz, tourmaline, &c., have been usually found. There is of course much speculation in this theory of M. Durocher; but the attempt to penetrate through the mystery which hangs over the production of the great variety of igneous rocks, and

to discover the mode in which nature worked in its internal laboratory, displays great ingenuity. In fact, geology has now arrived at such a stage that nothing short of a complete explanation of the great problem of the earth's history in all its relations, whether purely chemical, physical, or organic, will satisfy the philosophical geologist.

Geologists are all aware that the recognition, as an incontrovertible fact, of the increase of temperature in descending from the surface towards the centre of the earth, in whatever way the experiments may have been made, whether in Artesian borings, or in the shafts of mines, or by the examination of hot springs, was considered a certain proof of the existence of a source of internal heat, due to the retention of a portion of the original heat of the planet when in a state of igneous liquidity, by some part of the internal nucleus. When this theory was first propounded, many objections were urged in opposition to the fact itself, but when it had been satisfactorily proved that no accidental circumstances could account for the increase of temperature, the question appeared settled, and the theory was adopted without further hesitation. One remarkable circumstance had, however, been noticed, namely, that the rate of increase varied in different places, or in different deposits; and this fact has suggested, to our great physical geologist and former president, an *experimentum crucis*, to which he has subjected the theory. It is this,—that according to the ordinary law of the distribution of heat, the progressive increase of temperature from above downwards should be in an inverse proportion to the conducting power of the strata bored or sunk through. After a careful experimental examination of the subject, he comes to the conclusion that the rate of increase does not conform to this law, and, hence, that some other mode of explanation must be sought for, the fact remaining, as before, uncontroverted. It is hard to abandon a favourite theory so pregnant in deductions of great interest; and there can be no doubt that both the experiments and reasonings of Mr. Hopkins will undergo a rigorous examination; but should their accuracy be fully established, it will be better that we should be put upon a new scent and an active hunt, rather than be allowed to repose in an unwarranted confidence that we had solved so great a problem in the earth's history.

Another able investigator of the physical conditions of the earth is Mr. H. Hennessy, F.R.S., who, in a recent paper on the Physical Structure of the Earth, has brought forward additional developments and illustrations of the views he had already put forward in other publications. He quotes a result at which he arrived by a mathematical examination of the figure of a spheroid acted on by the abrasion of water, in order to show that the earth could not have acquired its present figure by the action of its watery envelope alone, as maintained by some distinguished philosophers.

Assuming, therefore, the earth to have been in a state of fluidity from intense heat, he proceeds to consider the way in which, according to known mechanical and physical laws, such a fluid mass may have passed into the actual condition in which we find our planet. He observes that the increase of density of the strata of the fluid in

proceeding from its surface to its centre, consequent on the overlying strata compressing those included within them, would render the process of "convection" very different from that which takes place in a homogeneous and limpid fluid, such as warm water, and thus the principal oscillations of the fluid would be confined to the vicinity of the surface. As explanatory of the influence of the viscosity of the fluid, the consolidation of the surface of lava-streams is adduced, as it shows how a continuous solid covering may be gradually formed over matter still continuing in a fused condition beneath. The probably imperfectly consolidated, porous, or scoriaceous condition of the first-solidified portions of such a fluid mass would, as he has subsequently remarked, greatly facilitate the formation of a solid crust; and if the first superficial pellicle of the earth's crust had been formed in this way, it would manifestly be much more easily disintegrated and removed than the harder and more slowly consolidated crystalline masses beneath.

In further considering the physical and mechanical actions by which the earth's internal structure may have been effected, Mr. Hennessy strongly objects to the adoption of the supposition, regarding the fluid matter from which the crust of the earth has solidified, that the change of consistence of the earth's materials produced no change in their distribution. This hypothesis he rejects as improbable, and considers it more philosophical to base our views regarding the changes of state in the earth's materials upon the evidence afforded by those materials which come under our actual notice. The nature of the earth's internal structure appears to depend greatly upon the manner in which its fluid portions have passed into a solid state; and Mr. Hennessy points out that a consequence deducible from his views of the earth's structure, and from a result obtained by Mr. Hopkins, would prove the existence of considerable pressure and friction between the fluid nucleus of the earth and its solid envelope. The physical causes on which this pressure depends are shown to be involved in the gradual increase of density of the fluid towards its central portions. The connexion of these views with that portion of geological dynamics which embraces the study of the greater elevatory movements on the surface of our planet is briefly pointed out. Without implying the correctness of all the conclusions stated by M. Elie de Beaumont, Mr. Hennessy is satisfied that the eminent French geologist has shown such an amount of connexion between very widely distributed phenomena of elevation as indicates the operation of general and wide-spread disturbing agencies beneath the crust of the earth. But, instead of attributing, with De Beaumont and Humboldt, these phenomena to the successive collapse of the crust of the earth upon a more rapidly contracting nucleus, Mr. Hennessy refers it to the pressure he had before explained. Illustrating his views from the equilibrium of arches, he shows that a pressure acting in the direction required to produce subsidence of the earth's crust upon the nucleus, would be far more resisted than a pressure acting in the contrary direction. The action of an interior expanding elevatory force upon the crust of the earth appears to

Mr. Hennessy more calculated to produce symmetrical relations in the lines of fracture and elevation of that crust, than the squeezing or crushing actions that would accompany a series of great subsidences. The obvious connexion between the disturbances of the crust of the earth and its thickness has produced some remarks on that point. If gravity were rigorously perpendicular to the outer surface of the earth's crust, its thickness might be extremely small compared to the earth's radius, or the earth might be solid from its surface to its centre: the manner in which Professor Stokes has deduced Clairault's theorem shows, as remarked by Mr. Hennessy, that the variation of gravity over the earth's surface, and other great statical and dynamical results of the earth's structure, would be then precisely the same, whatever might be its internal constitution. But although gravity acts perpendicularly to the surface of the ocean, that does not prove its perpendicularity to the earth's solid crust; and reasons are adduced for coming to a different conclusion; whence Mr. Hennessy infers that we cannot at present consider the thickness of the earth's crust as an inappreciable fraction of the earth's radius. On the other hand, he considers Mr. Hopkins's estimate of the thickness of the earth's crust as not conclusive, because it essentially depends upon the hypothesis that the process of solidification of the earth was accompanied by no change in the distribution of its particles.

The very clear explanation of the views intended to be expressed in his late essays, with which I have been favoured by Mr. Hennessy, has enabled me to put other physical geologists in a position to estimate their value; and I have thus done justice to one who is following closely and with great ability in the footsteps of Mr. Hopkins. The purely physical investigation of the phenomena of the earth's crust cannot be in better hands than those of our former president and of his two Irish coadjutors Hennessy and Haughton, whilst there are many of our members who are quite capable of following Dr. Daubeny in the purely chemical investigation.

Amongst the phenomena which still require much elucidation are those of metamorphism; and it appears to me that we are at present allowing our foreign friends to make a monopoly of that class of research. M. Delesse has, for example, distinguished himself by his efforts to clear up the difficulties which hang over the subject of metamorphism; and I shall therefore briefly notice his '*Études sur le Métamorphisme*' here, as a preparative for an abstract of his papers, which he has transmitted to me, and a translation of which I propose to insert in a future number of the '*Journal*.'

M. Delesse rightly observes that the term "metamorphism," taken in its more general acceptation, comprises all the changes through which rocks have passed; and it may indeed be said that scarcely any rock or stratum can be studied in its original condition, as every one, whether it be a sandstone, a conglomerate, a shale, a schist, a limestone, a trap, or a granite, has undergone some modification,—consolidation being a process subsequent to deposition, and crystallization subsequent to some form of liquefaction. He then introduces

the following classification as necessary to facilitate the study of so comprehensive a subject: viz., 1st, normal or general metamorphism, depending upon causes which have acted upon a grand scale, but generally in an imperceptible manner; 2nd, abnormal or special metamorphism, which depends upon partial causes, visible in their modes of action, and generally limited in extent. To this latter class of metamorphism, and more especially to metamorphism of contact, M. Delesse confines his attention at present, remarking that, though it is the most simple, it yet affords a vast field for inquiry; and in this restriction he acts wisely, as it cannot be doubted that the safest way to arrive at a correct conclusion as to the possibility of certain effects having been produced by the more obscure forces of nature, is to ascertain what those forces which can be observed almost in action, and which have some analogy (at least in results) with the forces which may be called into action in our laboratories, are capable of producing.

M. Delesse gives a goodly list of the various European and American authors who have in some one point of view or another, as M. Delesse observes, referred to the subject since the time when Hutton first brought it within the range of true science; but it must be admitted that many of these authors have merely referred to metamorphism as a matter of fact, and that some have occasionally assumed for it powers at variance with the laws, chemical and physical, of nature.

When a dyke or vein of intruded mineral matter can be so observed that the portion of the rock of deposition through which it passes exhibits the effect of its contact, whilst the portions distant from it retain their original condition, or rather their actual condition at the time of the eruption, there can be no reasonable difficulty in assigning the effect to its cause, though there may yet be a doubt as to the manner in which that cause had acted. One of the best methods of obtaining a clue to this very obscure question is to study the different effects produced on various substances by the same operating cause—bearing also in mind, that here, as in every exhibition of natural forces, action and reaction always accompany each other, the intruded rock acting upon the mineral matter through which it passes, whilst the latter reacts upon the intruded rock, the two forms of metamorphism being thus called by Cotta, direct and inverse, and by Fournet exomorphism and endomorphism,—citations which, it will be observed, I quote from M. Delesse. The effect of the direct action of the erupted rock is, however, generally greater than the inverse action of the rocks through which it passes, as its plastic state gives it a facility in penetrating and operating upon the more rigid materials of the enveloping rock, which the latter does not possess. Its action also is, doubtless, assisted (as suggested by M. Elie de Beaumont) by the filtration of water charged with mineral matter, or by the disengagement of gaseous and vaporous emanations from its mass. On this point, however, it is necessary that I should observe that the abstraction of certain portions of its elementary constituents from the intruded rock of eruption must

necessarily induce a very great change in its ultimate condition, quite independent of the possible introduction into its mass of other elementary constituents derived from the enveloping strata. Here, again, the examination of the reciprocal effects produced by the passage of erupted rocks through various substances has the advantage of not only showing the difference of the results produced on the enveloping rocks, but also on the erupted rocks themselves, which, however different they appear in their final condition, may possibly be reduced to the same original by such inquiries. As M. Delesse observes, quoting an old proverb, "just as the workman is known from his work," so also from the study of metamorphosed rocks may be traced out the true history of the erupted rocks which have produced them.

M. Delesse begins his inquiry with direct metamorphism, or that change produced on the enveloping strata by the erupted rock, and limits himself first to the effects produced by the eruption of truly siliceous rocks, such as lavas, trap-rocks, and granites. The term lava is restricted to those flowing mineral masses anhydrous in composition and manifestly of igneous origin. Trap-rocks are hydrated mineral masses, the base of which is a hydrated felspar of the sixth system, anorthose, and which may be therefore called anorthose rocks: they include basalt, dolerite, hyperite, euphotide, trap, diorite, hornblende-rock, greenstone, kersantite, &c., to which are added "Sherzolithe" and serpentinite. Granite-rocks contain, as an essential element, orthose felspar, and may be therefore called orthose-rocks: they include granite (as the type), syenite, protogine, porphyry, curite, minette, and *even gneiss*. The family of trachytes, containing vitreous felspar, belongs to the orthose-rocks; but, as some of them are hydrated rocks, such as retinite, perlite, phonolite, and even obsidian, the metamorphism they have produced differs in character from that of granitic rocks, and they must therefore be classed with the trap-rocks, so that all hydrated volcanic rocks are grouped together as traps. The metamorphism produced by granitic rocks is not so easily traced out as that proceeding from the action of trap rocks, since it generally happens that the enveloping rocks are also crystalline, and that it becomes therefore no easy matter to determine the line of demarcation between the granitic nucleus and the granitic envelope, or to distinguish between the action of special and of general or normal metamorphism. M. Delesse therefore begins by explaining the metamorphic action of trap-rocks; and he investigates the effect produced on mineral substances such as the ores of iron, on combustible substances, on feldspathic rocks, on limestones, and on siliceous and on argillaceous rocks, first citing the actual facts he has either observed himself in nature or in well-authenticated specimens, then describing the erupted rock and bringing into comparison the original and the metamorphosed condition of the rock upon which it has acted,—the principal mineralogical and chemical characters of all these being carefully determined, so that both the physical changes of structure and density, as well as the alteration of composition from the loss of particular elementary substances,

may stand revealed. At this point it may be observed that M. Delesse soon convinced himself that the effect of heat as an agent of metamorphism has been much exaggerated, and even that porcelainite, so often assimilated as an igneous product to the vitreous slags of furnaces, which are produced by the action of beds of coal in a state of ignition, has only very partially owed its production to heat. Nor is this all, as he considers that the same remark applies to various other rocks, both metamorphic and eruptive, the formation of which has been exclusively ascribed to heat.

To solve a question of this kind, M. Delesse first submitted the various rocks to the action of heat in the laboratory, as the effects upon some substances may be very great, and upon others very slight. The prismatic structure which the lining of furnaces assumes by heat has often been noticed, as also the vitrified scoriaceous condition assumed by many substances; but all these bear about them marks of their origin which are easily recognized. As the action of heat necessarily varies with the composition of rocks, M. Delesse briefly notices the peculiarities of metamorphism which they exhibit: thus, combustibles lose their water and volatile constituents, and are converted into charcoal or coke, but are never by heat alone transformed into anthracite,—the temperature necessary for producing these effects being much less than is usually supposed, as the heat required for distillation of the bituminous matters ranges from 500° in turf and 572° in lignite, to 752° in coal and anthracite, or in all cases a temperature below red heat. On this point M. Delesse observes that, admitting the progressive increase of temperature in penetrating towards the interior to be at the uniform rate of 1° for 60 feet, the highest temperature above named would be possessed by a rock erupted from a depth of about $9\frac{1}{2}$ miles,—whilst the great change produced by the expulsion of the larger portion of the water of the combustible substances being effected at a temperature little above 212° , the eruption of a rock from a depth of $2\frac{1}{2}$ miles would be sufficient to produce such an effect. I need scarcely observe that this reasoning simply implies that an increase of temperature proportionate to the depth below the surface of the earth is an observed fact, and leaves untouched the question as to the true cause of that increase. It is only necessary to name the other agencies which M. Delesse cites as capable of abstracting the bituminous and volatile matter of combustibles, such as benzine, itself a product of the distillation of coal, alkalies and alkaline carbonates, and highly heated currents of water, charged with mineral and especially alkaline matter, traversing the beds of combustible matter when situated deep in the interior. M. Delesse indeed concludes from this latter fact, that the difference between lignite, coal, anthracite, and graphite is rather due to the metamorphic action produced by this aqueous action than to a simple dry distillation.

Pure calcareous rocks would lose by heat alone their carbonic acid, and be brought as caustic lime into a condition to undergo further change; but marls or impure limestones might enter into fusion, and thereby undergo a complete change. Sulphate of lime, even at

a temperature of 248° , loses its water; and, if heated to a much higher temperature, does not regain it; so that it may be reasonably assumed that contact with an igneous rock of intrusion would change gypsum into anhydrite.

The action of heat upon siliceous rocks is somewhat different in character, and had been the subject of a previous essay of M. Delesse. Their fusibility diminishes with the increased amount of their silica; and they fuse either into a glass or into a scoria more or less crystalline, at the same time being diminished in density, and after fusion being readily acted upon by alkalies.

As prismatic sandstones are often found in contact with trap-dykes, M. Delesse has tried what the effect of the action of alkalies would be on a sandstone forming the lining of a furnace, and which had assumed a prismatic condition as the effect of heat. This sandstone was very quartzose and cellular, or melted only in some few points. When boiled in a concentrated solution of potash, $\frac{4}{5}$ of the silica was extracted,—this experiment proving that, by the joint action of heat and the alkaline constituents of an igneous intrusive rock, the metamorphic effects would be considerable, as the rock is brought by the heat into a condition in which it becomes subject to the alkaline action.

It is manifest that hitherto M. Delesse has estimated the effects produced under the simplest aspect of the operations of natural causes; but, as in nature the causes are complicated or combined (for example, in volcanos, where heat acts in the interior of the earth subject to the modifications due to pressure and the action of vapour and disengaged gases), he then proceeds to give examples of the alterations both of minerals and of rocks by subterranean ignition such as often occurs in coal-mines. The heat thus produced, and under such circumstances, has been found sufficient to volatilize the water, and disengage the carbonic acid of the argillaceous carbonate of iron, and to produce a considerable change in its physical characters, whilst combustible substances have also undergone material alteration in such a process. In this latter case, the carbon being dissipated, the ashes are sometimes too refractory to melt, as at Menat in Auvergne, where the ash proceeding from the spontaneous combustion of a bed of lignite is a schistose and pulverulent tripoli coloured red by oxide of iron, whilst in other cases they have melted and are vitrified. Considerable change may be effected also even where the combustibles are not burnt, as the observations of M. Drian, quoted by M. Delesse, prove—on such natural combustions at the Montagne de Feu near Lyons. The first alteration is indicated by the coal becoming iridescent; by a further change it becomes cellular and cavernous, as well as harder and more brilliant, and finally passes into a coke with metallic lustre: and such alterations have been extended to a distance of several yards from the ignited coal, the metamorphosis here produced being analogous to that observed in contact with trap-rocks. Siliceous rocks are acted upon nearly in the same manner as by ordinary calcination: they lose their water or other volatile constituents; they become, if argil-

laccous, agglutinated together, tinted of various colours, ribanded like jasper, still preserving traces of stratification, fragile, hard, and sonorous, of which porcellanite is an example, and if the temperature be very high, they are melted and form vitrified substances, just like the slags of a forge or furnace. These subterranean combustions yield also volatile and sublimed products like volcanos, as, for example, the combustible gases, vapour of water, specular iron, sulphur, hydrochlorate of ammonia, and other salts. It is right, however, to observe, that though the identity of the effects produced by artificial calcination with those produced by the combustion of beds of coal or lignite is fully established by these observations, it can hardly be said that the conditions are those of rocks exposed to intense heat under great pressure, and totally excluded from the air.

This latter case is more nearly represented by the effects produced by lavas, which is the next subject of the inquiries of M. Delesse, who names all those authors who had preceded him in such investigations. At the Puy de Montchié, in Auvergne, trunks of trees, more or less carbonized, are found imbedded in the volcanic debris which forms the base of the Puy. The charcoal thus formed is of a rich black colour, and of a metallic lustre; it is friable, very porous, light, and soils the fingers; it has preserved its original woody structure, and by MM. Lecocq and Bouillet is considered to have belonged to the birch. It is readily combustible; and its composition, as determined by MM. Lecocq and Bouillet, is—carbon, 52·50; white ashes, consisting of carbonate of lime, with traces of silica and alumina, 5·00; loss by ignition, 42·50; so that it is evident that the water and volatile matter had not been fully expelled by the igneous rocks, to the action of which the combustible body had been exposed.

The composition of another example of wood carbonized by lava, from Auvergne, M. Delesse found to be—carbon, 18·75; ashes, 46·48, consisting of carbonate of lime, 6·21, oxide of iron with a little alumina, 40·27; loss by ignition, 34·77. As charcoal formed artificially contains, when manufactured in damp air, not more than 20 per cent. of volatile matter, it is clear that, even in this example, calcination under such circumstances has only partially expelled the volatile matter of the wood, whilst both analyses show that the charcoal has been impregnated with mineral substances; so that the black or red charcoal, produced by the action of the lava which, as at Vesuvius where these effects may be studied, envelopes the wood or other vegetable substances, is in a much more advanced stage of metamorphosis than any artificially-formed charcoal. Felspathic bodies undergo very material change from contact with lava: thus the granite of the Roches Rouges, near the Puy, has assumed a prismatic structure; the fragments of granite of Denise, near the Puy (Haute Loire), imbedded in a volcanic scoria, have been partly melted, and have assumed a cellular structure, the cavities being due to the dissipation of the mica, which is the most fusible of the constituents of granite, whilst the quartz, which is the least, remains distinguishable.

Many other examples of the fusion, either partial or entire, of

granitic rocks are cited, the effects being similar to that produced on granite in a glass-making furnace, the quartz alone resisting the action of the heat; but M. Delesse observes that, independently of fusion more or less complete, felspathic rocks become impregnated with "fer oligiste" and other sublimated products of volcanoes, and have, like other rocks, been sometimes attacked by acid vapours. In fact, metamorphosis, under such circumstances, depends on the action and reaction between the active rock and the rock acted upon, as also upon the effects produced by other agencies, due to the eruption of gases and vapours, simultaneously with the principal agent, the erupted rock.

In calcareous rocks it is remarkable that, though in general they are, by contact with lavas, rendered crystalline and granular, or in some cases highly saccharoid, like marble, they appear on other occasions to have undergone scarcely any alteration. This metamorphism, due to heat combined with pressure, has been well understood since the experiments of Sir James Hall, confirmed as they have been by those of several subsequent chemists: M. Delesse observes, however, that neither a great amount of pressure or of heat is necessary to produce it, and adduces as a proof the production of crystalline stalactites, and even beds of a similar limestone, without the aid of heat,—an example not, however, in my opinion, analogous, as in this case the molecules have been enabled to move by a previous solution of the body in water, whereas in the other the cohesive attraction between the particles required the action of heat to allow mobility. It appears to me, indeed, that the occasional absence of the effects of metamorphic action indicates that in such cases the pressure had not only prevented the escape of the volatile constituents, but had also neutralized the effort of heat to destroy the force of cohesion, and thus to allow the particles to move amongst themselves. If so it is due to some modification in the circumstances, as yet to be explained by positive facts, though easily guessed at as a speculation. Other more complex effects, such as the introduction of magnesia into the rock, or (in the case of the saccharoid limestone of Somma, specially studied and described by M. Delesse) numerous minerals, are due to the reactions before noticed in respect to felspathic rocks, the limestone being originally marly or impure. Pure siliceous rocks, such as quartz, are acted upon in a similar manner to granite, but have been less affected. Fragments of quartz found imbedded in lava have become opaque, and have been fissured, but rarely melted, and then chiefly on the surface. The presence of an alkaline solvent may, however, contribute to a mere perfect solution; and then the silica would be absorbed in the mass of the lava.

The effect of metamorphic action on argillaceous rocks is less complete, as the surface may be vitrified, and no alteration produced on the interior; still, however, gaseous matter has in some instances been expelled, and a cellular internal structure has been the result. M. Delesse then sums up the effects thus: either a calcination more or less complete; the assumption of a stony, cellular,

or vitreous structure; sometimes a complete solution, probably partly due to the water combined with the rock.

I hope that what I have said will give a fair idea of the systematic and able manner in which M. Delesse has treated his subject advancing step by step from the simple to the compound, the laboratory of the chemist leading to Nature's present laboratory the volcano, and that again to the more recondite sources of metamorphism, viz. trap-rocks; but, as to follow him through the latter would require an inordinate space, I must merely content myself by observing that the same order is observed, and that every step of the investigation is illustrated by numerous examples, either based on the observations of others, or on his own, as well as by the chemical analysis of many of the products of metamorphism,—whilst the results are striking proofs of the value of M. Delesse's inquiries, and of the ability with which he has pursued them. In respect to combustible substances, he deduces from his inquiries that they appear under four aspects, corresponding to the different degrees of normal or general metamorphism, namely graphite, anthracite, coal, and lignite, and then illustrates the action of the trap-rocks upon each. New Cumnock in Scotland has afforded many illustrative specimens, originally collected by M. Boué, but analysed by M. Delesse, though here it is rightly assumed that the coal has passed through the several stages of metamorphism up to anthracite, and finally graphite, through the action of the trap, having become impregnated in the course of the change with a large amount of mineral matter. The lignite of Omenak in Greenland, collected during the recent voyage made by Prince Napoleon, and, where in contact with the trap, metamorphosed into anthracite, exhibits even more striking results, as by analysis it is found to consist of carbon 50·64, water and traces of bitumen 15·60, carbonate of lime 18·43, of magnesia 6·27, of iron 2·03, alumina 7·08; the anthracite having become useless as a combustible, being highly impregnated with mineral matter, sometimes in the form of veins. Whilst, however, these are the effects of contact with trap-rocks, M. Delesse points out, from various examples, that coal and anthracite, when imbedded in the trap, may have escaped such external metamorphism,—as an illustration of which, he cites the combustible, apparently a lignite, of Dellys in Algeria, observed by M. Ville, which, though imbedded in trap, has not passed into the state even of charcoal or of coke, as it would have done in contact with lava; but has been simply changed into a dry coal, which under distillation yields bituminous and ammoniacal matter.

M. Delesse deduces from this partial change a reason for considering the heat comparatively feeble; but I am more disposed to ascribe the differences of result to the more or less porous character of the enveloping trap, and the consequent greater or less facility with which the volatile ingredients might have escaped from the combustibles, although it is very possible that the heat in this case may not have been very excessive; and the impregnation with mineral matter indicates, as in other cases, that the metamorphism is due in part to other causes, and not to heat alone. The change produced is,

indeed, of two different kinds, which point to differences of action, as, for example, the production of a more compact combustible, whether coal, anthracite, or graphite—the density being increased; or the production of a truly carbonized substance, in which more or less of the volatile matter has been removed, and its density diminished. M. Delesse offers some theoretical considerations on the subject of this description of metamorphism. The prismatic character so frequently observed he attributes to simple contraction or desiccation, not requiring a very high temperature, and he cites the fact, that some combustibles, when dried in the air, lose a part of their volatile constituents, and assume a prismatic character: the introduction of mineral matter he ascribes to filtration, aided in most cases by aqueous solution, and points out how the action of trap-rocks upon the usual sedimentary rocks of the earth's crust, all being more or less saturated with water, must produce streams of hot water, which, acting upon the rocks, will become charged with saline and alkaline matter, and thus become a powerful instrument of metamorphism, first by removing the volatile matter of combustibles, and then by acting chemically upon them through the instrumentality of the matter held in solution.

The action of heated water, penetrating either by fissures or through the pores of a rock, may often explain cases of metamorphism where no igneous rocks can be traced,—for example, in the Alps, as quoted by M. Delesse, where combustibles of the jurassic age have been converted into anthracite. Scotland and Ireland, as well as other countries, including North America, have afforded numerous examples of the effects produced on rocks of various geological ages and physical structure; but, tempting as the subject is when handled by M. Delesse, I shall now leave it, confidently trusting that some of the able chemical philosophers of our own Society and country will be induced, by what I have said, to give M. Delesse the gratification of knowing that he has kindled enthusiasm in the minds of those so fully qualified to follow his example. M. Delesse adopts the same system of inquiry as Bunsen and Senft* in Germany; and I hope that ere long we shall have our own chemical geologists, in Houghton, Galbraith, and others.

The papers or essays which I have hitherto noticed afford good examples of the purely chemical and physical modes of investigating the condition of the earth's surface; the one I am now about to notice introduces a new principle of examination, and is peculiar to our own member Mr. Sorby. The microscope has unquestionably done most important service in many delicate investigations connected with both inorganic and organic tissues; and all must remember the beautiful results displayed in the 'Odontography' of Owen, and in the works of Carpenter, Quekett, and Bowerbank: but it was reserved to Mr. Sorby to apply this powerful instrument to the examination of the internal structure of rocks, and to deduce from it many philo-

* We are indebted to Mr. J. Morris for an excellent abstract, in the 'Journal,' of the able work of Dr. Ferdinand Senft. It supplies what was wanting in the mineralogical classification of rocks by Brongniart, namely, their chemical analysis.

sophical conclusions of high interest. Mr. Sorby's application of the results of his inquiries to the explanation of the phenomena of cleavage is fresh in our recollection; and he has since pointed out the misapprehension of his views which even Professor Tyndall has shared with many others. Mr. Sorby intended to show that the compressive force, which he considers essential for the production of cleavage, acting upon the unequiaxial particles of mica, would lead to their arrangement in planes corresponding to those of the induced cleavage, and, consequently, that the cleavage in slate-rocks is more perfect in proportion as the quantity of mica present increases; and he further states, "there are scarcely any rocks whose particles are not unequiaxed, and I must still maintain that, other circumstances being the same, those have the best cleavage that are composed of particles whose length and thickness differ most." It is therefore not as being the primary cause of cleavage, but as influencing its degree of perfection, that Mr. Sorby cited the mode of arrangement of the particles of mica in slate and other rocks; and few will doubt that so far his reasoning is correct, as the planes of crystallization will naturally become coincident with the planes of cleavage. In his paper on the "Limestones of Devonshire," Mr. Sorby, in a similar manner, endeavours to show that the unequiaxed particles have by compression been thrown into planes, perpendicular to the direction of pressure, which have become the points or spaces of least resistance of Professor Tyndall, or those in which, according to my view of the case, the reaction to pressure exceeds the cohesive force, the planes in fact of least cohesion. In another paper, also of recent date, Mr. Sorby endeavours to prove that the terraces in the Valley of the Tay, north of Dunkeld, have been "formed by the combined action of the river and of the sea when it was at a relatively higher level;" and this idea he ingeniously supports by showing that the stratula of the bands of ripple-drift, or drift-bedding, dip on the whole along a mean line to one side, being that to which the current flows or in which the directing pressure is applied, just as in his previous experiments in the preceding paper,—a current therefore which alternately moves in two directions naturally giving rise to successive opposite dips of the stratula. Having ably maintained his views, Mr. Sorby judiciously adds, "it must not be supposed that I wish to make it appear that the terraces in all other valleys are due to the same cause,—as one set of circumstances may have formed some, and another set others. Nothing, in my opinion," he adds, "can be a greater obstacle to a correct interpretation of such phenomena, than to conclude that all things which appear *similar* are actually *identical* and have had a *similar* origin,"—remarks, in the truth of which I fully concur.

In the papers of Mr. Sorby which I have been noticing, the microscope was applied to the elucidation of the manner in which the constituent particles of rocks had been arranged, and thereby to the explanation of the true character of some important physical phenomena. In the paper which Mr. Sorby contributed to our proceedings during the present session, the same instrument has been applied to

the examination of the "Microscopical structure of Crystals, with a view to the determination of the Aqueous or Igneous origin of Minerals and Rocks," which is one of the most abstruse and difficult questions in physical geology. As a general rule, it must of course be admitted, that the molecules of any substance must be endowed with a power of movement before they can arrange themselves into any definite form; and, as regards mineral substances, it has therefore been always considered necessary that they should be in a state of solution before the elementary constituents, of which they are composed, could rearrange themselves into a definite crystalline form. Taking, in the first place, notice of artificial crystals, since the whole process can in them be brought under actual observation, Mr. Sorby points out that, though the cohesive force of the particles is reduced to a minimum, it is not absolutely destroyed, and hence that, in the act of crystallizing, portions of the solvent surrounding them at the time of formation would be often caught up and enclosed within their solid substance. When, therefore, crystals are produced by sublimation, either air or vapour is imprisoned, which, on being condensed by cold, leaves apparently *empty cavities* or *air-cavities*; when the crystallization is from an aqueous solution, *fluid-cavities* are formed; when from an igneous solution, the crystals which separate themselves from the *fused-stone solvent* may be expected to catch up and entangle in their substance some portions of the mineral bath, which on cooling resume their original character, and produce what may be called *glass- or stone-cavities*. The differences between these several forms of cavities can be readily distinguished with suitable magnifying powers, and thereby afford the means of determining under what conditions the crystals had been formed: as, for example, crystals containing only fluid-cavities, from aqueous solution; crystals containing only *stone- or glass-cavities*, from igneous fusion; crystals containing both *water-cavities* and *stone- or glass-cavities*, from the combined influence, under great pressure, of highly-heated water and melted rock: and, further than this, that in the case of fluid-cavities, the amount of water present affords a datum for determining, from the amount of condensation it appears to have undergone since the original formation of the cavity, the temperature it possessed when entirely filling the cavity. In like manner, Mr. Sorby considers that empty cavities indicate that the crystals containing them have been formed by sublimation, unless there is reason to believe that the enveloping matter was sufficiently porous to allow the imprisoned fluid to escape, or that the cavities were merely bubbles due to fusion. The number of cavities may be expected to increase with the rapidity of crystallization, whilst a total absence of cavities indicates either very slow crystallization, or the cooling of a fused homogeneous substance. These general principles are then applied by Mr. Sorby to the study of natural crystalline minerals and rocks; and he deduces from them many highly interesting results: for example, that the *fluid-cavities* in rock-salt, in the calcareous spar of modern tufas, in vein-stones, in ordinary limestone, and in gypsum, indicate that these minerals were formed by deposition from solution in water, at a temperature not materially different from

the present—a conclusion which equally applies to other minerals found in the veins of various rocks,—whilst the many fluid-cavities in the constituent minerals of mica-schist and the rocks associated with it show that the metamorphism to which they have been subjected was due, at least in part, to the action of heated water, and not alone of dry heat and partial fusion—a conclusion which should be compared with some of the deductions of M. Delesse.

The structure of the minerals in erupted lava shows that they were generally deposited from a mass in the state of igneous fusion; but as in some of the blocks ejected from volcanos, crystals are found which contain *water-cavities*, in addition to stone- and glass-cavities, it may be fairly assumed that they were formed under great pressure, when both liquid water and melted minerals were present, and that the minute crystals which the fluid-cavities of these aqueo-igneous minerals generally contain have been deposited on cooling from the highly-heated water which once filled the cavity. The minerals in trap-rocks appear to have been of genuine igneous origin, though they have been subsequently much altered by the action of infiltrating water, from which many other minerals have been also deposited.

The quartz from quartz-veins appears to have been rapidly deposited from solution in water, the temperature of which must, from the diminished volume of the water by cooling, have been considerable, about 329° ; at a still higher temperature, mica, limestone, and probably even felspar were deposited, showing, as has been asserted by M. Elie de Beaumont, a passage from quartz-veins even to granite, and that the one therefore can scarcely be separated, as a rock of deposition, from the other as a rock of purely igneous fusion. Whilst, indeed, in the quartz of highly quartzose granite, the liquid-cavities are so numerous as to number millions even in a cubic inch, and the water they contain amounts to 1 or 2 per cent. of the volume of the quartz, so that they might be considered the result of an aqueous solution, both the felspar and quartz exhibit stone-cavities exactly similar to those in the crystals of furnace-slugs or of erupted lavas, and therefore indicate the conjoint action of igneous fusion. The great conclusion which Mr. Sorby draws from this fact is, that granite is not a *simple igneous* but, rather an *aqueo-igneous* rock, produced by the combined influence of liquid water and igneous fusion, under similar physical conditions to those existing, far below the surface, at the base or focus of modern volcanos. These deductions of Mr. Sorby are in conformity with the views of Scrope, Scherer, and Elie de Beaumont; and he even agrees with them in considering it probable that the difference between erupted trachytic rocks and granite, both of which are included by M. Durocher (in the paper on which I have already commented) in the same class, as proceeding from the same *magma*, is due to the presence or absence of the water.

In whatever light we regard the paper of Mr. Sorby, whether as founding upon microscopical observations a new explanation of the conditions under which rocks have been formed, or as proving from them the intimate association of water with the constituents of minerals, independently of the simple water of crystallization, it cannot

but be received by the Society as a striking exemplification of the zeal, originality, and success with which he carries on his researches in physical geology. *

Cleavage.—In my last address I was necessarily obliged to enter at considerable length upon the subject of cleavage, in order to do justice to the labours of our late most distinguished and most lamented President, and I shall therefore refrain from anything more than a very brief reference to what has since then come under my notice. The report upon cleavage presented to the British Association in 1856, or anterior to my address, but published subsequently, has been divided into two sections: the first, of a historical and descriptive character, is that which has now appeared; the second, which will be theoretical, is reserved for a future period. With his usual ability Professor Phillips has corrected some errors of detail in the observations of his predecessors; and it may be said that he clearly establishes the following phases in the progress of a subject which he justly characterizes as English; viz., 1st, the recognition of the necessity of a great leading or general cause, instead of a partial or accidental one, by Professor Sedgwick; 2nd, the more perfect connexion of cleavage with pressure, by the methodical application of the phenomena of distorted shells to its explanation by Mr. D. Sharpe; 3rd, the illustration of many points connected with cleavage, by the microscopical investigations of Mr. Sorby; 4th, the experimental investigation of the effects of pressure in producing cleavage, by Professor Tyndall. The “fundamental generalization” of Professor Sedgwick, to use the expression of Professor Phillips, has been illustrated by many observers, and especially by the two brothers Rogers in their graphic account of the Appalachian chain in the United States; and I will only add, that whilst there can be no doubt that cleavage has, in many of the cases which came under the observation of Mr. Sharpe, been the result of pressure, it still remains to prove that pressure has been the only cause of cleavage—or at least that pressure has always acted in the same manner, in order to bring within the scope of calculation some of the examples cited by Professor Phillips, such as “waved cleavage,” “cleavage varying in its angle according to the variation in the mineral composition of successive strata,” &c. In my last address I gave my opinion as to the natural law upon which cleavage might be supposed to depend; and I must still say, that when Professor Sedgwick expressed the idea that the cleavage in mountain-masses is so regular as to appear like the results of enormous crystallization, he seems to have exhibited that keen appreciation of natural phenomena for which he has always been remarkable, and to have had in his mind the fact that crystals, being formed by the apposition of successive layers of molecules drawn together by the force of affinity, subsequently cleave in the direction of these layers—the cohesive force between the molecules of any one layer being greater than between the molecules of two adjacent layers. At the last meeting of the British Association, Professor Haughton illustrated his preceding calculation of the effect of pressure in distorting organic remains, by an ingenious model, which showed that

as a general rule, there is not a greater extension of a distorted fossil in the line of the dip than in that of the strike of cleavage.

Glaciers.—The researches of Professor Tyndal on the properties of ice and the phenomena of glaciers having been alluded to in the preceding remarks, it seems to me desirable to offer a few observations on that interesting subject; for, though glaciers are not at present recognized as having at a comparatively recent epoch extended their action over a vast extent of the earth's surface, plain as well as mountain, they have been still more intimately connected with the general history of the earth, by the researches made, especially by Professor Ramsay, to detect traces of their past action, not merely on ancient rocks, but within the periods during which such rocks were deposited. The great difficulty in accounting for the progressive movement of glaciers, is to provide a sufficient force to put such ponderous masses into motion, and to keep it up notwithstanding the retarding force of friction. Some of the earliest investigators, as Saussure, considered the force of gravity as sufficient to produce motion, whilst the melting of the ice in contact with the earth reduced the friction to a minimum, or, in the words of Mr. Mallet, placed as it were liquid rollers under the ice. Anterior, however, to this mode of explanation, the Swiss philosopher, John Jacob Scheuchzer had advanced a totally different one in his *Itinera per Helvetiæ alpinas regiones*, a work which was published by Vaudon of Leydeff, in 1723, and dedicated to Sir Isaac Newton, then President of the Royal Society, of which Scheuchzer was a member. Scheuchzer observes that the movement of glaciers requires not to be explained by any miraculous agency, but is entirely dependent upon natural causes; for he adds, "*Solet nempe aqua a tergo montium rupiumque glacialium defluens; vel in fissuris ipsis et interstitiis aliis glacialibus collecta, et utrobique congelata, quoniam amplius in hoc statu requirit spatium (contestantibus id experimentis circa frigus et glaciem institui solitis), undiquaque premere et eam quidem glaciæ partem quæ liberum aërem respicit, et pascua declivia actu ipso propellere, et una eam glaciæ arenam, lapides, saxa etiam grandiora, quo ipso hyperbolica illa purgatio simul explicari et facile intelligi potest.*" All will remember the ingenious manner in which Agassiz, following Charpentier, adopted and applied this theory, by assuming that a multitude of capillary cracks are formed at night,—that water produced by the melting of the ice on the surface by the sun's rays during the day filters into the cracks, and is frozen and therefore expanded at night, when, by the expansive force of so many frozen seams of water, the ice is put in motion, new cracks are formed, and all is ready for a repetition of the same results. This theory was at first as popular as the simple gravitation-theory had at first been, when Professor James Forbes, considering it too hypothetical, entered upon the investigation of the subject, and, after most laborious personal researches in the Alps, guided and supported as they were by the light and vigour of his philosophical mind, brought forward facts and reasonings not merely to overthrow the hypothesis of Agassiz, but to prove that, however difficult it may be to reconcile the motion and the other phenomena of glaciers with the gravitation-theory so long as the

glacier is considered to be composed of solid ice, his observations tended to show that all the phenomena are analogous to what might be expected in a moving semifluid or pasty liquid like lava, and hence that a glacier ought to be considered ice in this imperfect state of condensation. However difficult it has been to ordinary observers to convince themselves that the ice they saw before them with its lofty pinnacles and its huge crevices, and which they could split with an axe into angular fragments, was a semifluid substance, the theory of Forbes has yet for several years been received as a satisfactory explanation of the phenomena; but Professor Tyndall has now satisfactorily proved that the structure of ice (a structure which had been previously ably illustrated by M. Schlagintweit) is such that it can be readily crushed into its constituent particles, and again by pressure reconsolidated, so as to conform to all the variations of form of the mould through which it is forced. The comparison of the results of direct experiment at the laboratory of the Royal Institution with the actual phenomena of the glaciers themselves has convinced Professor Tyndall, and I may fairly say every one who has listened to or read his lectures upon the subject, that his explanation of the mode in which ice is enabled to pass through all the accidents of movement, and to change its form without losing its continuity, is as satisfactory as it is philosophical; but it must be evident to all, that the theory of Professor Tyndall explains all the phenomena of glacier-motion, but not the cause of that motion. Professor Forbes had this latter point in view when propounding his theory of semifluidity; and we must now look to Professor Tyndall, who stands, from his zeal, intelligence, and high mental training, in the foremost rank of Alpine observers, to clear up the only difficulty now remaining.*

Descriptive Geology.—The great zeal with which palæontological research has been pursued, and the vast accession to the numbers of extinct animals and plants, have necessarily required the cooperation of the most able naturalists with the geological explorer, in order to ensure a correct determination of the epochs of the earth's history by the peculiarities of their respective faunæ and floræ. The geologist

* On this point I think it right to refer to the paper of my respected friend the Rev. Canon Moseley, F.R.S., on the motion of glaciers, published in the 'Proceedings of the Royal Society,' and in which he adopts the facts of Forbes and Tyndall as being satisfactorily established. He considers the motion due to the successive expansions and contractions of the ice according to the variations in its temperature, just as in any other solid, and independent of the congelation of water which may have filtered into its cavities. This theory he illustrates by a curious fact, observed first in a scientific manner by himself, at the Cathedral of Bristol. The sheets of lead with which a portion of the building had been covered are observed to descend gradually down the inclined plane of the roof, even tearing out the nails by which they have been fastened to the rafters, and that solely by their successive expansion and contraction. This substitution of the simple principle of the contraction and expansion of the ice as a solid body, each tending to promote its descent on an inclined plane, for the hypothetical one of the expansion by congelation of water filtering into either the crevices or cracks, is unquestionably very ingenious, although some of our able philosophers have considered it insufficient to account for phenomena exhibited on so large a scale. Mr. Moseley, however, is about to reply to the objections of Professor Forbes and others in a second paper on the subject.

now receives organic remains after they have been critically examined and described by the zoologist or botanist, and has only to apply them to the practical objects of his own science. Whilst, however, it is easy to allot to the palæontologist and to the geologist their respective tasks, it is not so easy to separate the objects of physical geology from those of pure or descriptive geology, upon the same principle that a perfect geographer may be expected to be conversant with both natural and physical geography: it is, indeed, the object of the geologist not only to determine the age of a deposit, but also the physical circumstances under which it was formed. The latter and truly philosophical branch of the subject has always been a favourite study of our able fellow-member, Mr. Godwin-Austen; and in the paper I am about to notice, he founds upon a simple fact a very ingenious speculation. The "fact" is, that in the chalk about two miles south of Croydon was found a boulder of granite, associated with other detritic materials. Prior to reasoning upon this fact, Mr. Austen gives a very reasonable definition of the term "extraneous," by which he understands that a fossil, or other body, is found in a position not in accordance with its original habits, or the place of its formation, as, for example, a "deep-sea mollusc amidst a number of the inhabitants of shallow water," or a boulder of granite in a chalk- or clay-deposit. This definition is sound and important, as it points out to the palæontologist the necessity of determining the natural habitats of fossils, as well as their names, and to the geologist the necessity of separating the extraneous from the native fossils, before he can make a satisfactory comparison between the deposits of different ages. Mr. Austen reviews the history of fragments of "extraneous" rocks previously found in the Chalk, and then proceeds to draw the conclusions, which, though I have named them speculative, I do not consider the less philosophical and important. All the fragments he has noticed appear to have been water-worn, and therefore must have been moved or acted upon by water. Some of them exhibit marks of the *Serpula*, &c., which attach themselves to bodies resting for a time on the lower or quiescent portion of the "marginal sea-belt," whilst others, more especially the smaller or shingly kind, from their smooth surface, would appear to have formed part of the upper portion, which, from its position, is subject to the constant disturbance of the waves. D'Orbigny and Edward Forbes, as quoted by Mr. Austen, were of opinion that the pure white chalk was the deposit of a deep and open sea; but Mr. Austen shows, from the application of such reasoning as I have here noticed, that every other form of sea-bed, from the abyssal to the marginal, existed in the Cretaceous period. On the one hand, for example, the presence of sand, gravel, and occasional boulders under the circumstances detailed by Mr. Austen have proved the existence of a marginal zone before the deposition of the upper portion of the chalk; and, on the other, the presence of forms of Bryozoa and of other fossils which when alive must have been fixed at the base, detached in the body of the chalk, show that such fossils are "extraneous" in the position where they are found, and must have

been moved down from a more marginal locality, before they were imbedded. Many other examples are given of this forcible removal of fossils from their original locality, and their subsequent deposition in the deep-sea bed; but I need not follow Mr. Austen through the details of this inquiry, as no one will now hesitate to admit that all the means of transport which now exist, such as the tidal wave, floating ice, floating trees, sea-weed, &c., are as likely to have been in operation within the Cretaceous epoch. Some of these (as, for example, ice) may, as suggested by Mr. Austen, have been modified in their action by a difference in the physical circumstances of the then existing dry land and sea; but all may have more or less contributed to the results produced. I will only further observe that Mr. Austen investigates with great ingenuity the form and composition of the dry land of the chalk-period,—as, for example, he shows that the Cretaceous strata of many localities indicate littoral conditions, and therefore that the older rocks (whether gneissic, granitic, or slaty) which are now in close proximity to them must have even then been in the condition of land-surface. I shall not follow Mr. Austen in his attempt to trace out the coast-line during the Cretaceous epoch; and I will conclude my remarks on his paper by observing that he has appropriated to himself a class of research which is difficult in proportion to its apparent obscurity, but which he is likely by his skill and perseverance to place very high amongst the objects of the philosophical geologist.

A short paper by Mr. Prestwich again brings under our notice the ingenious speculations of Mr. Austen, and goes far to prove their accuracy. It refers to the recent borings for water at Harwich, in which the artesian well has been carried to the depth of 1070 feet, having passed through the superficial drift, the tertiary strata, chalk, upper greensand, and gault; but below these well-known strata, the normal rocks or deposits which ought to have appeared were deficient, and a mass denominated a black slaty rock appeared instead, as shown by the fragments brought up, and examined by Mr. Prestwich. In the Kentish Town well, the chalk was found to be underlaid by rocks which lithologically appeared to belong to the Triassic epoch, but the evidence was not considered conclusive: in the present case Mr. Prestwich considers the proof of the absence of a large portion of the normally underlying rocks to be satisfactory; and, though he is unable to satisfy himself whether the rock arrived at belonged to the Carboniferous or to the Silurian epoch, yet that the evidence in both the Kentish Town and Harwich wells is sufficient to warrant him in adopting, at least in part, Mr. Godwin-Austen's hypothesis of the extension of an underground tract of the older rocks, ranging from the mountains of the Ardennes in Belgium to the Mendip Hills in the West of England, and therefore breaking the continuity of the Lower Greensand under London. The actual form of this ancient palæozoic land, Mr. Prestwich considers to have been a broken ridge rather than a broad tract; and this is unquestionably the most in conformity with the probable elevatory cause of its existence. Even though Mr. Godwin-Austen may never have the gratification of

hailing the discovery of a coal-deposit under London or in its neighbourhood, the penetrating powers of his mind have been fully established by these practical results.

One of the papers contributed by Professor Phillips has a close relation, in one respect, to those I have last noticed, as it endeavours to explain the physical conditions under which some of the strata of Shotover Hill, near Oxford, have been deposited. Tracing the history of discovery in respect to these deposits from 1722 to 1827, it appears that the sandy strata which on this detached hill rest on the Portland series, and with their associated ochre have received the general title of Ironsand, being by Conybeare referred to the Hastings group, had, until the latter date, afforded no organic clue by which the physical circumstances under which the deposits had been formed could be inferred. Dr. Fitton then ascertained the occurrence of Purbeck deposits at Whitehugh in Buckinghamshire; and about 1832, the Rev. H. Jelly discovered Paludiform shells in the sands of Shotover; and this discovery, confirmed by Mr. H. E. Strickland, was published by Dr. Fitton in his well-known memoir "on the Strata below the Chalk." Mr. Strickland added a *Unio*; and Professor Phillips himself has still further added to the list of fossils which I will call physically characteristic. The word "Portland" is in the mind of most geologists associated with the idea of the "Portland Limestone;" but the words "Portland Rocks" have a much wider acceptance in this paper of Professor Phillips, and refer, not alone to a calcareous form of deposit, but to the green sands, clay-bands, and layers of subcalcareous concretions, rich in fossils, which here mark more than the age of a deposit; for, whilst the fossils *Pecten*, *Perna*, &c., mark the aggregate of 70 feet in thickness to have been marine, another overlying group of strata, about 80 feet thick, consisting of various coloured but not green sands, bands of clay, layers of peroxide of iron, and cherty masses, is as decidedly marked to have had a partially freshwater origin by *Unionidae*, *Paludina*, and other mollusca, which, though some may be considered as possibly marine, mark distinctly at least the cooperation of fluviatile action, and, combined together, establish the existence of an estuary—rather than a lacustrine formation. Professor Phillips therefore infers that the Shotover Sands are a northern equivalent of the Hastings Sands; but, from the difference in the species of *Unionidae*, he suggests the probability that the river which was the cooperating agent in producing the deposit was a different stream from that of the typical Wealden, and that its effects will be traced much further to the north-eastward. Without doubt, these deductions from facts are deeply interesting; but what a wide field they open for speculation, since, the course of the river being traced by its effects, its banks are yet to be discovered! I cannot help also observing that the species of *Unionidae* appear to be remarkably local, or at least that the variations in form from one locality to another are so great as to render them admirable guides in distinguishing one estuary from another belonging to the same epoch, but not equally so for estimating the relative ages of deposits,—a remark which has been strongly im-

pressed upon my mind by the great number of local species which that eminent conchologist, Dr. Lea of Philadelphia, has even recently established and described. The object of another paper of Professor Phillips was, in a great measure, to bring under the notice of geologists the great difference in mineral aspect, and the only partial agreement in fossils, of the oolitic regions of North Yorkshire and the South of England, and, whilst attempting to settle the real affinities of some of the calcareous beds in the Yorkshire series with some of the well-established members of the Oolitic group of the South of England, to facilitate the determination of the geographical range of the ironstone, coal, and limestone of Yorkshire, and of the physical conditions of the sea or estuary in which they were deposited. When I observe that, by the close examination of two great general sections, Professor Phillips has proved the existence in the lower oolitic series of five distinct plant-bearing bands of sandstones, of shales which occasionally yield coal arranged in three zones, of four calcareous bands, and of several layers of ironstone, it must be admitted that he has brought before us most remarkable alternations in the physical forces in action at the time; but he has gone still further, by describing the geographical range or distribution of these varied deposits, and tracing out the relation of the lines of deposition, called by him "isochthonal lines," with the general strikes and dips of the strata, or in other words the lines which mark the limits of each varying condition of the deposits, from marine to estuarine. I need not enter further into the details of this paper; but I may observe that, as Professor Phillips proposes to resume, at a future period, the discussion both of the geographical range of the fossils, and of the physical conditions of the sea-bed already glanced at in this paper, he affords us another proof of the high advance in geological science of the present day. At one time it was supposed that palæontology had entirely done away with the necessity of studying the mineral characters of deposits; but now we find that the mineral character is essential for the right understanding of the fossils, as indicating the physical conditions under which they have been deposited.

A portion of the same geological division of strata engaged the attention of Mr. A. Geikie, one of the members of the Geological Survey of Great Britain; and the results of his investigations are given in a paper on the Geology of Strath, Isle of Skye. The previous writers on this somewhat complicated district are enumerated, namely, Jamieson, Macculloch, Murchison, and Edward Forbes,—the first of the latter two writers having, however, been principally instrumental in determining the existence and limits of strata belonging to the lias, and the lower and middle oolite, whilst Edward Forbes, in seeking for the equivalents of the English lias and oolite, ascertained that the Oxford clay has its equivalent in Skye. The district examined by Mr. Geikie is a narrow belt, from three to six miles in breadth, which extends across the narrowest part of the island from sea to sea, and in area is about thirty square miles. Including, as it does, the largest development of the lias in Scot-

land, and as, in its lowest and middle divisions, it attains a thickness of 1500 feet, it compensates for the small area by the important reflections to which it may well give rise in respect to its former physical conditions, as so deep a deposit in so small a space must be considered only a relic of a much greater whole; and we may well say, with Mr. Geikie, that the intricate and confused character of the geological structure of Skye gives to the liassic beds an additional and peculiar interest. Considering the state of knowledge at the time when Macculloch published his 'Western Islands,' and the imperfect maps he had to guide him in his researches, we may well excuse some errors in marking the limits of strata, even in so acute and able an observer; and it is therefore no real disparagement to him that others have since been able to discover and correct them.

As a fact it is remarkable, that the Lias in Scotland rests on either a metamorphic or palaeozoic base, usually the Old Red Sandstone, and that it is confined to the northern counties, among the hypogene and older palaeozoic districts. The Lias of Skye is sometimes conformable and sometimes unconformable to the underlying red sandstone, a purplish-grey quartz-rock; but, as these rocks have hitherto yielded no organic remains, it cannot be positively determined whether they belong to the Old Red, the Silurian, or the later portions of the gneissose series of Central Scotland.

Mr. Geikie traces the limits of the sedimentary deposits, and describes their mineral character as well as their organic relations, and then in a similar manner notices the various igneous or erupted rocks, which have, without doubt, given rise to much of the complexity of the district. This paper is accompanied by a very valuable list of the fossils collected by Mr. Geikie from the Lias, drawn up by Dr. Thomas Wright, who prefaces the list by a brief definition of the sense in which he understands the term "Middle Lias." He here repeats his former opinion, that the terms Upper Lias, Middle Lias, and Lower Lias, as used by English geologists, require modification, in order to place the "basic" beds in correlation with those of French and German authors,—modifications which in his opinion require the basic beds of the Inferior Oolite to be transferred to the Lias, as the "Upper Lias Sands," and the beds which, with the Marlstone, were the upper beds of the Lower Lias, to be considered the basic beds of the Middle Lias.

Following up this idea, Dr. Wright gives a table showing the condition of the Lias-beds in France, Germany, Gloucestershire, and Skye, in which these alterations are exhibited. This is a disputed point, to which I shall again have to refer. I shall only further observe that Dr. Wright first gives a list of about 86 characteristic species of Mollusca and Radiata of Gloucestershire, and then compares those collected by Mr. Geikie, which are identified (as already-described species) with them. These are principally from the shales of Pabba, which Dr. Wright, as the result of the comparison, places at the base of the Middle Lias, under the Marlstone. As there are 25 of such Pabba species, the deduction is made from a more enlarged basis of comparison than in the case noticed in my last address, and

is unquestionably treated with an evident desire to arrive at the truth. *Pleuromya Scotica*, *Gervillia Maccullochii*, *Pentacrinus robustus*, and *Isastraea Murchisonii* are new species added to the fossil fauna by Dr. Wright, who also states that the *Gryphæa Maccullochii* (Sowerby) is the true *Gryphæa Cymbium* of Lamarek: as determined from the observation and comparison of the Pabba specimens, it is in his opinion a Middle Lias species, both in England and France.

I have hinted in the preceding remarks that I should have again to notice the question, mooted by Dr. Wright, of a proposed modification of the position assigned to the sands of the Inferior Oolite by English geologists. I had then in view the paper by Professor Buckman on the Oolitic Rocks of Gloucestershire and North Wilts. It is gratifying to observe that the two important sections used as illustrations for this paper are the result of surveys made by the professors and students of the Royal Agricultural College of Cirencester, as they are thus a practical exemplification of the importance of combining geology with agriculture—a subject so forcibly dwelt on by our late friend, Mr. Trimmer. After noticing the labours and reviewing the opinions of preceding writers on the Oolites, and more especially on the lowest part of the series, Professor Buckman declares himself opposed to the views of Dr. Wright, and considers that he has not produced sufficient evidence for associating the so-called “Sands of the Inferior Oolite” with the Lias. He admits indeed that some of the shells from the fossiliferous sands are peculiar, and have sometimes (especially a few of the Ammonites) a Liassic aspect, but at the same time contends that the greater portion of the fauna, including the local and non-migrating Mollusca, is *characteristically oolitic*, and that the two more characteristic Liassic Ammonites, on which especially Dr. Wright relied, were not merely “extraneous” fossils, to use the phrase of Mr. Austen, but actually obtained from the true Lias, far below the sands in question. The cause of this mistake is supposed by Professor Buckman to have originated from the decomposed state of the surface of the Lias here, and the fact that it is masked by an overflow of the sand from above, so as to have led Dr. Wright to think that the fossils were in the sand itself. Professor Buckman deserves much credit for the pains with which he must have instructed his pupils and laboured himself in working out the details of the whole oolitic series; and it appears to me that the question at issue between him and Dr. Wright is in itself instructive. To determine that a fossil is extraneous, it ought to be shown that the bed in which it is found is, from its physical characters, incompatible with the organic conditions of its existence. The physical conditions of the Liassic and Oolitic beds are different; and it might be expected therefore that they should have supported many organisms peculiar to each, independently of any question of age. Should, therefore, a bed exhibiting the physical conditions of the Lias appear immersed in the Oolites, and in it be found a Liassic fossil, it cannot be assumed that such a fossil is extraneous, however its appearance may militate against our opinions of the age of the deposit. Should, however, the fossil be found imbedded in a stratum

totally dissimilar to the bed which marks the character of its natural habitat, it cannot be received as any other than an extraneous fossil and ought to be rejected from the list of characteristic fossils. In geology there should be no spirit of partisanship, as the object is not to support the territorial rights of formations, but to arrive at truth. Such, I am sure, is the object of Professor Buckman; and as he promises hereafter to offer further remarks on the physical conformation of the Oolitic district he has described, we may expect that this question will then be finally settled. In like manner, I am satisfied that Dr. Wright, when convinced that he has, in this particular case, been led into error, will frankly admit it.

A paper by Professor D. T. Ansted on the geology of the Southern part of Andalusia, between Gibraltar and Almeria, brings the Jurassic beds under notice, with some little variations in the physical characters of the rocks with which they are associated. Having described the mica-schists of the Sierra Nevada, he states that in the north-west they are overlaid by a crystalline limestone, on which repose thick beds of tertiary marls. Beds of shale in some places are interpolated between the schists and the limestones; and near Malaga they pass into a conglomerate, and then into triassic and jurassic beds. The old schists and the shales are traversed by serpentine-veins which, in the absence of fossils, serve as a proof of their general identity. East of Malaga the Professor observed a black fossiliferous magnesian limestone (distinct from the true dolomites), which underlies shales and sandstones, the upper grit-bed containing *Calamites* or *Equisetites*. This limestone he considered the equivalent, as regards position, of the conglomerates between the shales and sandstones above mentioned; but as the first-named shales were said to pass into the conglomerate, and at the same time were closely connected by the serpentine-veins with the mica-schists, there appears much complexity, as might have been expected, in these partial (or at least locally-studied) deposits.

The limestones of the Sierra de Gador pass towards the west into the light-coloured limestones of Gibraltar, and are considered jurassic—a red marble at San Anton being probably Cretaceous, and an overlying calcareous breccia the base of the Tertiary series. On this latter rock rests another limestone of oolitic structure, but associated with a Nummulitic rock. All these are followed by a series of Upper Tertiary strata, the lower beds rich in Foraminifera, and the others exhibiting one of those curious alternations of land and freshwater fossils, with beds abounding in the most marked marine fossils. The more recent raised sea-beaches close the geological details of Professor Ansted's paper; but, as his great object in visiting Spain appears to have been the investigation of its mineral treasures, I may observe that irregular deposits of argentiferous copper occur in the mica-schist, that galena is found in the first-mentioned crystalline limestone, that copper-ore is also found in the beds of shale (which is another link between them and the mica-schist), and, finally that enormous deposits of galena are found in fissures which traverse the supposed jurassic limestones,—results which sufficiently prove

the importance of geological knowledge to the practical mineralogist.

Our indefatigable member Capt. T. Spratt, R.N., has extended his inquiries into the Eastern part of the Dobrutchá, and has favoured us with some remarks in continuation of his former paper. The flanks of the Northern chain of mountains, in itself composed of highly inclined limestones, shales, and slates, are smoothed down, as it were, by a deposit of arenaceous and variegated marls. These marls are considered of recent date; and though not fossiliferous, Capt. Spratt now considers that this group of superficial marls of the Steppe is distinct from the freshwater marls, or lower freshwater deposits, of Kustenjch. At the north-east of the Dobrutchá there are older rocks, which Capt. Spratt considers to be in a metamorphic condition from volcanic action, and, in his opinion, to have been either Devonian or Carboniferous; to them he assimilates the thick beds of dark shale which occur at the south-west corner of the Rusein Lagoon, where the Delta of the Danube commences; they resemble the shales and schists on the flanks and base of the Balkan, near Cape Emmench. In the east-cliff a secondary limestone is observed to overlie the shales, whilst it immediately underlies the superficial earthy marls of the Steppe. Capt. Spratt had no opportunity to search for fossils amongst the deep beds of shale, sometimes amounting to 500 or 600 feet in thickness; but the fossils found by him in the limestone appear, from the examination of our Assistant-Secretary, Mr. Rupert Jones, to correspond with those of the secondary section of the white limestone of the Mediterranean: and I use the term "section" because, as I have on a previous occasion observed, the same physical condition is preserved in the limestone from the Jurassic into the tertiary epoch as is shown in the Ionian Islands, and more especially in the Island of Paxos, where Nummulites in great abundance occur in connexion with flints, and with the general characteristic appearances of the hardened chalk. Some of the physical changes which have taken place in this region are highly interesting. The limestones Capt. Spratt supposes to have stood as ridges, rocks, or islets in a freshwater lake, which once covered, in his opinion, the whole area of the Black Sea and Archipelago, and which has left evidence of its existence in several freshwater formations, both of marls and limestones. Following in succession the hard porcelain-like limestone, Capt. Spratt notices a chalk-marl and a limestone of a more truly cretaceous character; but even these would appear not to be clearly determinate in age, were it not that Mr. Jones states that a *Ventriculite* and Cretaceous *Foraminifera* occur amongst the fossils. I shall conclude my brief notice of Capt. Spratt's researches by observing that the base of the tertiary system is in several localities observed to be, as at Varna, and at Sevastopol on the opposite shore, a limestone oolitic in structure,—a fact which confirms my observations of the continuance of a prevailing mineral type through a vast range of organic life.

Another brief but very interesting paper, "On the freshwater deposits of the Levant," may be considered supplementary to the

preceding, as its object is to trace out the boundaries, and determine the age of a great Oriental lake or chain of lakes which embraced the Dardanelles, Sea of Marmora, and perhaps part of the Mediterranean, as indicated by the detached or fragmentary deposits along the ancient margin. This is a noble speculation; and I will only add that Capt. Spratt, who invites the attention of geologists to the subject, has proved himself a very able pioneer of their researches.

During the late war, the occupation of part of the Crimea by the allied armies brought within the scope of observation the geology of a country, which, although it had been previously examined, still left much open to further investigation. Had the proposition which was made at the commencement of the war, to attach a scientific committee to the army, been carried into effect, there cannot be a doubt that much most valuable information would have been obtained towards the correct correlation of the strata of the Crimea with those of England; but, even as it was, some of our officers found time, amidst all the dangers and privations of that most remarkable campaign and siege, to collect materials for geological investigation. Amongst these intellectual soldiers, Capt. F. Cockburn, Royal Artillery, was one who not only worked hard to collect a series of fossils and rock-specimens illustrative of the geology of the neighbourhood of Sevastopol and Balaklava, but who wisely placed them in the hands of our able member, Mr. W. Baile, for description; and the result is a very copious list of fossils, which have been well illustrated by three lithographed plates. The range of strata extends from the shales of the Woronzoff road (described by M. Dubois de Montpérenx as the oldest fossiliferous deposits, and considered by Mr. Baile to be equivalent to the Lower Lias) through Jurassic and Cretaceous strata, up to the Steppe Limestone, which, though often oolitic in character, is proved to belong to the Newer Tertiaries,—an example which, like those I have before cited from Capt. Spratt's and my own observations, exhibits the long continuance of the same physical conditions, notwithstanding the variation in the imbedded organisms. Specimens of the various intrusive volcanic rocks which have disrupted the strata, and doubtless effected much metamorphic change, were also collected by Capt. Cockburn, who observes that the upper Tertiaries, occurring sometimes shelly, sometimes sandy, and then again as oolitic limestones, are generally marine, but sometimes freshwater, and are occasionally associated with volcanic ashes and tufa. Mr. Baile, in working up the materials placed in his hands by Capt. Cockburn, first does justice to all the preceding authors who have either given descriptions of the geology of the district, or of other districts having an immediate connexion with it—not overlooking Keyserling, De Verneuil, and Sir R. Murchison—and then proceeds to the examination of the fossils, the lowest geological formation noticed in his list being Jurassic. The number of species passed under review was 286, of which 60 are described by Mr. Baile as new. The proportions in the several formations are as follows:—

| | Before-described | | | Total. |
|----------------------------------|------------------|--------------|-----|--------|
| | Species. | New Species. | | |
| Jurassic or Lower Secondary..... | 44 | 16 | 60 | |
| Cretaceous or Upper Secondary.. | 106 | 11 | 117 | |
| Older Tertiary | 24 | 0 | 24 | |
| Newer Tertiary | 52 | 33 | 85 | |

It is somewhat remarkable that 0·26, or above $\frac{1}{4}$ th of the lower secondary, and ·39, or above $\frac{1}{3}$ rd of the newer tertiary, are new fossils, whilst in the upper secondary less than $\frac{1}{10}$ th are new, and in the older tertiary no new fossils at all were discovered. I do not draw from this circumstance any other conclusion than that much more must be done before a perfect correlation of the strata can be effected: and I cannot help hoping that all the specimens will be hereafter carefully drawn and published; for it is almost impossible to determine the identity of those which have been compared only with the figures of foreign works, without having carefully-executed plates to examine; and it is to be hoped that hereafter the museum in Jernyn-street will become complete in typical series of specimens with which all foreign specimens may be collated. Several other military names are mentioned as having been contributors of the specimens, such as Lieut.-Col. Munro, Major Anderson, R.A., Major Cooke, R.E., Major Hudson, 39th Regiment, Dr. Sutherland, Dr. McPherson, and Mr. Olver. Many of these names have been given to the new species; and I would have been happy to relinquish the honour conferred in one instance upon me, in favour of some of the others.

The judicious remarks with which Mr. Baily concludes his paper show an alternating approximation to and divergence from the British types. Thus, for example, in the lowest division there is a close approximation to our Lias, whilst there is a considerable divergence from the Oolites. In the Cretaceous group there is again a tolerable resemblance to the several British divisions; and even in the Lower Tertiaries there is some; whereas the Middle or newer Tertiaries, constituting the Steppe Limestone, and forming one of the most important members of the whole series in the Crimea, are very distinct from the British Tertiaries in fossils, and are believed to have formed part of the deposits of the great Aralo-Caspian Sea, which was probably even larger than the present Mediterranean.

Mr. Baily has turned to good account the opportunity afforded him by Capt. Cockburn; and I trust Capt. Spratt, and Dr. Abich, who is also engaged in this interesting research, will bring these observations into comparison with their own, and by their continued labours assist in rendering the whole complete.

Permian and Trias.—Every day's experience has added fresh proof of the difficulty of accurately discriminating between detritic formations when in close contact with each other; and it may be fairly said that it would never have been possible to allot to the Magnesian Limestone of England its true place in geological classification, had not Sir Roderick Murchison discovered in Russia all the

elements necessary to constitute a distinct formation, and recognized the Magnesian Limestone of England, the Zechstein of the Continent, and several detritic members as belonging to the new formation he then established under the name Permian. The general correlation of the strata of both the Triassic and Permian formations of the Thüringerwald and Hartz had been before pointed out by Sedgwick, Murchison, King, and Morris; and it is the object of Mr. Edward Hull, in his paper on the Odenwald, to inquire how far a similar parallelism could be traced between the Triassic strata of Germany and of England. In the Odenwald, the Permian strata are very limited, and are identified with the formations of the Thüringerwald and Hartz, or with the trappoid breccias of Worcestershire, almost entirely by lithological characters; but as the Zechstein appears, though sparingly, at Heidelberg, the fact of the existence of Permian deposits may be safely admitted. Mr. Hull had in 1854 pointed out three well-defined subformations in the Bunter Sandstone of England; and it was his principal aim to ascertain whether this member of the Trias is similarly subdivided in Germany,—a species of minute correlation attended with much difficulty. The sandstone of the Odenwald has been sometimes classed with the Permian; but after a careful examination, and depending on mineral resemblances, Mr. Hull considers it Triassic, and the representative of the middle one of his three divisions of the English Bunter, viz. the conglomerate-beds of the West of England,—the two other divisions, or the upper and lower variegated sandstones, being here wanting. But though this sandstone exhibits only one form of physical deposit, it attains a thickness equal to that of all the three English subdivisions, and may therefore be their full equivalent. The Muschelkalk, being absent in England, does not admit of a comparison; but Mr. Hull concludes, as the general result of his examination, that the three divisions of the Permian as established by Murchison, and the four divisions which, as regards mineral characteristics, have been noticed in the Keuper, have all their representatives both in England and in Germany. A tabular view is given of this correlation of the deposits; and as Mr. Hull regrets that he was unable to extend the range of his inquiries to the Vosges, we may hope with him that he will at a future day be in a position to obtain more complete data for this class of deduction.

Professor Nicol has brought under our notice some phenomena connected with the New Red Sandstone of Loch Greinord, in Ross-shire. Preceding authors had noticed the occurrence on the shores of this loch, of two small patches of red sandstone, and suggested their apparent relation to the Red Marl, or New Red, of England. Professor Nicol, after making due mention of the labours of Macculloch, Sedgwick, and Murchison, points out the manner in which the newer sandstone overlies the older formation, the stratification being at a low angle. The underlying sandstone, notwithstanding some peculiarities, Professor Nicol identifies with the quartzite of the neighbouring mountains, and he finds the newer sandstone deposited, in a very remarkable manner, among the broken edges of the older strata.

As even the calcareous matter occasionally connected with the sandstones has hitherto produced no fossils, the determination of age must depend on other considerations, such as the position of the beds and the fragments of rocks they contain; and on such evidence Professor Nicol concludes that the upper formation belongs to a *far more recent* period than the underlying sandstones. To connect it, however, with still more recent formations is a matter of difficulty; great numbers of fragments, however, of a compact white limestone are scattered on the shore near Tinasuline, opposite to Island Ewe, and, having been but little worn by transport, appear to be the remnants of a formation now worn away. The fossils they contain show that the formation must have been the same as the Oolite of the North of Skye (which therefore must have once had a very considerable extension), and add to the probability that the red sandstones were all upper members of the Trias, or perhaps of the Lower Lias; and that these small patches are also relics of a much more extensive formation. Professor Nicol offers some interesting observations on the variation in the amount of metamorphic action; and closes his paper by pointing out what he considers to have been glacier-moraines—one ridge of boulders of gneiss and other rocks having been the terminal, and another the lateral moraine of a glacier cradled in the mountain-valley in which Loch Fuir now lies.

Of other papers, less directly falling into the divisions of the subject I have adopted, one by Mr. R. Brough Smyth is of much interest, as it brings under our notice a district in the Colony of Victoria, Australia, remarkable for volcanic products and other evidences of recent igneous action. This district is represented as 250 miles in length, and 90 miles in breadth; and Mr. Smyth enumerates many hills of various heights (some as much as 700 and 1500 feet) in which either craters can be traced, or marked relics of volcanic action discovered. An interesting letter from Mr. Selwyn, the colonial geologist, states that one of them, "Tower Hill, is certainly the most recent volcanic vent he had seen in Victoria," as the ash and scoria emitted during its later eruptions rest on beds of shell, sand, and earthy limestone containing numbers of the living littoral species of Mollusca. The crater now forms a lake.

Whilst granite appears to be the basic rock of the Victoria system, Mr. Smyth recognizes two eruptions of basalt—the most ancient having penetrated the Palaeozoic and Tertiary strata, and the newer having not only penetrated these, but overflowed the Tertiary (forming, it is presumed, a sheet of submarine lava), being, however, sometimes underlain by an intervening bed of hard quartz rock, and overlain by a quartzose drift, and by the recent volcanic lava. The Tertiary beds are, from their fossils, considered of miocene age; they do not appear to have been disturbed by the eruptions, but continue horizontal. The streams of lava are in some places more than 25 miles in length, and of great thickness; and the occurrence of auriferous deposits around the centres of eruption, and the contiguity of the extinct cones to the great volcanic chain which extends from the Aleutian Isles to New Zealand, give, in Mr. Smith's opinion, a pecu-

liar interest to this exhibition of volcanic forces in action almost up to the historic period. It is, indeed, yet to be determined whether the number of still active volcanos is equal to, in excess of, or in defect of the number of the extinct.

The Rev. Samuel Haughton, Fellow of Trinity College, Dublin, and Professor of Geology in that University, has submitted to us his further researches into the chemical constitution of the granites of Ireland, which I might perhaps have noticed more appropriately in a preceding portion of my address. In his former paper he expressed his opinion that the granites of the neighbourhood of Newry, like those of Leinster, belong to two distinct types, namely, potash- and soda-granites,—those south of a north-east line drawn through Newry and including the Mourne granites belonging to the potash-type, whilst those to the north of the line belong to the soda-type. In the present paper Professor Haughton supports this opinion, first by the chemical analysis of granites selected from five localities south of the line, in which there is a general resemblance in the composition of all, the potash exceeding the soda in amount in the proportion of 4 and 5 to 3, and then by a similar analysis of the soda-granites from four localities, which, however, do not exhibit the same regularity of composition, whilst the proportions are reversed in respect to the soda and potash, the soda being now in excess.

The atomic proportions of Silica, Peroxides, and Protoxides in the two types of granite are as follows:—

| Potash-granite. | | Soda-granite. | |
|-----------------|-------------|---------------|-------------|
| Silica | 1.582 | Silica | 1.429 |
| Peroxides | .. 0.311 | Peroxides | .. 0.367 |
| Protoxides | .. 0.301 | Protoxides | .. 0.294 |

And the mineral composition,

| Potash-granite. | | Soda-granite. | |
|-----------------|-------------|---------------|-------------|
| Quartz | 18.36 | Quartz | 21.24 |
| Felspar | 76.66 | Felspar | 41.45 |
| Green Mica | .. 5.00 | Mica | 36.50 |
| <hr/> | | <hr/> | |
| 100.02 | | 99.19 | |

The composition of what Professor Haughton terms a “pink elvan or soda-elvan-dyke,” he deduces from his analysis to be,

| Soda-elvan. | |
|-------------|-------------|
| Quartz | 29.52 |
| Felspar | 60.15 |
| Hornblende | 8.81 |
| <hr/> | |
| 98.48 | |

—hornblende being in this instance supposed to replace the mica. These pink elvans penetrate the granite. From all his observations, both in Down and in Wicklow (in the examination of which latter county he was assisted by Mr. Jukes), Professor Haughton concludes

that the potash-granites are the normal type, and that other granites are formed by the addition of bases. He also points out the great difficulty in deciding on the quantities of the component minerals by the eye alone, and adds that, though the potash-granites of Leinster are more persistent in external character than the Newry granites, the latter are quite as regular in chemical composition.

A section of the gravel-beds at Taunton, in Somersetshire, was contributed by Mr. J. Pring; and the very last paper of our late member, Mr. Joshua Trimmer, was on his favourite subject, the distribution of the superficial detritus which covers up most of the consolidated, and hence, in part, metamorphosed, strata of the earth. In the Goslstone cliffs of Norfolk, Mr. Trimmer recognized an upper and a lower Boulder-clay; and this very fact proves that the old so-called diluvium was the result, not of an abnormal and instantaneously acting cause, but of a long-continued series of natural causes, marked in this case by the recurrence of glacial phenomena at two successive periods. Mr. Trimmer considered this portion of the earth to have been gradually sinking at the time, and to have been thus subjected to the overflowing of the northern wave, carrying with it fields of boulder-charged ice.

Having thus incidentally referred to the preceding minor papers, I shall close this notice of papers on Descriptive Geology by a brief commentary on the two papers which Sir R. Murchison has read before the Society during the present session. Nothing can be more gratifying to us, or more encouraging to our younger members, than to observe the undiminished energy with which Sir Roderick strives to put the last finishing touch to his labours on the rich subject of Silurian deposits. The first of the two papers was a supplementary comparison of the Silurian rocks and fossils of Norway as described by M. Theodor Kjerulf, with those of the Baltic provinces of Russia as described by Professor Schmidt, and both with their British equivalents. In South Norway there is a vast development of *unfossiliferous* rocks, which, as in our own country, are denominated Cambrian; but we may at least hope that hereafter, even in these unpromising rocks, the same success will attend the searchers for fossils as has already rewarded our British inquirers, and that it will be ascertained without doubt whether any epoch antecedent to that of Siluria was marked by organic life. The recent discovery, by Mr. William Rogers, of the genus *Paradoxides* in the metamorphic rocks (ordinary mica-slate) of the neighbourhood of Boston, United States, is one additional proof that we ought not to despair of making many similar discoveries, some, as in that case, within the Silurian epoch, and others probably far antecedent to it. M. Kjerulf divides the Silurian system of Norway into three groups distinguished by their physical characters, or, in other words, by the conditions under which the several deposits had been formed; and these he names from the localities where they can be best studied, the Oslo, the Oscarskal, and the Malmo or upper group; and then further establishes fourteen subdivisions.

The sandstone and conglomerate at the base of the Oslo group is

unfossiliferous; but it is followed by fossiliferous schists and limestones. The Oscarskal group is composed of calcareous and argillaceous rocks, including Enderbital schists. The Malmö group is argillaceous at its base, with calcareous flags and a Pentamerus-limestone, an upper Orthoceras-limestone, and an upper Graptolite-schist,—repetitions which strongly prove that they are but the natural alternations of mineral deposits, accompanied by a corresponding variation in the organic structures which belong to any one great geological formation. The total thickness of the fossiliferous rocks is above 1900 feet; and Sir Roderick classes the lower and the upper Oslo and the Oscarskal series, or the lower eight subdivisions, with the Lower Silurian as representing the Stiperstones, the Llandeilo, and the Caradoc series, and the lower and upper Malmö, or the six upper subdivisions, with the Upper Silurian as representing the Llandovery, the Ludlow, and the Wenlock series.

In the comparison of the fossils of the Silurian basin of Christiania with those of Great Britain, Sir Roderick has of course found many specific differences; but the coincidence in the succession of the fossils, considering the distance between the localities, is stated to be truly remarkable, and without doubt it is by this correspondence in the change of organic life in two different and distant regions that their identity as formations must be determined, rather than by an actual identity of species, which ought not to be expected under such circumstances. Occasionally, however, common species step in to decide on the true value of a bed; and thus the alum-slates of Norway, which from its Trilobites had been supposed to belong to a peculiar zone, are by *Orthis calligramma* and *Didymograpsus geminus* brought into direct connexion with unquestionable British Lower Silurian deposits, such as the Stiperstones and Longmynd rocks. Taking indeed the whole thickness of the Scandinavian beds with all their subdivisions, Sir Roderick maintains that, though so much less extended in development than the British, it constitutes one conformable and natural system, whether viewed physically or zoologically. Where pierced by eruptive rocks, some of the members of the Silurian series have been metamorphosed into crystalline gneiss—a fact which has been confirmed by Mr. David Forbes.

The Silurian deposits of Esthonia and Livonia, as described by M. Schmidt, differ in physical character from those of Norway, as calcareous bands constitute the greater portion of them. M. Schmidt recognizes five stages, each of which is characterized by a peculiar fauna,—very few species traversing two entire stages, some being present in the two upper, and some in the two lower, whereas only one species, the *Culymene Blumenbachii*, passes through the five lower stages, being, however, in the fifth, the equivalent of the Upper Ludlow, modified into *C. spectabilis* of Angolín. The sharpest separation is between the second and third bands, or between the Lower and Upper Silurian, though there is even there a sufficient transition to show that there has been no “violent break in the development of organic life,” or such as could warrant the separation of the lower from the upper Silurian as part

of one great natural-history system. I need not follow further the ingenious and successful effort of Sir Roderick to prove that the system of classification which he was the first to originate in England is equally applicable to every country in which the more ancient palaeozoic deposits have been noticed; and perhaps in nothing is the truth of the proposition more manifest than in the position of the Pentamerus-zones; for, as Sir Roderick points out, the same species of *Pentamerus*, *Atrypa*, &c. occur in two successive bands in England, thus uniting together the faunæ of the lower and upper Silurian. The Pentamerus-zone in Esthonia is simply the central link of an unbroken Silurian chain—the former being the result of accident or physical disturbance, the latter the normal condition of the deposit. It is, indeed, the object of Sir Roderick to prove that in Scandinavia, as in Russia, Silurian rocks, both lower and upper, copiously charged with characteristic fossils, form a united and unbroken whole, and, viewed both palaeontologically and geologically, exhibit a natural-history system quite as complete and more easily understood than their more expanded, but much dislocated equivalents in the British Isles. Species may indeed change, or undergo variations so great as to be considered different; but the grouping of the whole will always enable the geologist to determine that he has arrived at a Silurian deposit.

The last paper of the official year was also by Sir Roderick Murchison, and is directed to the elucidation of the succession of rocks in the Northern Highlands. The object of this paper is to rectify both the opinion which had been previously formed, that the mountain-masses of red conglomerate and sandstone of the west coast of Scotland were detached portions of the Old Red Sandstone, and that of Professor Nicol, that the quartzite and limestone occurring in this series might be considered an equivalent of the Carboniferous series of the South of Scotland. It will be observed that this latter opinion was based on certain fossils found in the limestone of Durness by Mr. C. Peach, and that Sir Roderick founds his alteration also upon the fossils, after a determination of their true nature by Mr. Salter. Sir Roderick first describes the fundamental or true gneiss, which is the basis of the whole series, then an accumulation of quartz-rocks, crystalline limestones, chloritic and micaceous schists, and younger gneiss. The fossils from the quartz-rocks consist of small Annelide-tubes, now called *Serpulites Maccullochii*, and traces of fucoids; they have been traced in beds for long distances by Mr. C. Peach. The strong band of limestone between two quartz-rocks contains, however, fossils of a higher degree of organization, namely, a species of the genus *Maclurea* (*M. Peachii*, Salter) and its curious twisted operculum, the genus being one formed by our American friends; again, *Ophileta compacta*, a Canadian fossil, *Oncoceras*, and a smooth species of *Orthoceras* with compressed siphuncle. They all resemble Lower Silurian fossils of North America, which range from the Calciferous rocks up to the Trenton limestone, but especially grouped together in the limestones of the Ottawa River in Canada. Following up the succession of rocks to the eastward. Sir Roderick

states his belief that the limestones intercalated with the chloritic and quartzose rocks of Dumbartonshire are unquestionably of Lower Silurian age, and that the overlying masses of mica-schist and quartzose-gneissic flagstones of the Breadalbane district may be some day found to be merely the prolongation of the micaceous flagstones of the North-Western Highlands, described as overlying the quartz-rocks and fossiliferous limestones.

The inquiry was then extended, ably and extensively, into the Devonian system; and, after many judicious observations on the divisions and arrangement of this great formation, Sir Roderick maintains the importance of the Devonian series in the scale of formations, and that the Old Red Conglomerates, ichthyolitic schists, and cornstones, with the overlying sandstones of Scotland and Herefordshire, fully represent, in time, the Devonian rocks of the South of England and the Continent, so full of corals, crinoids, and marine mollusks.

It is impossible, in noticing this paper, not to dwell for a moment on two interesting points connected with it; namely, that the recognition of the Silurian age of the Durness deposit should have been made, not through the intervention of a comparison of its fossils with those of the closely approximate Silurian regions of England, but with the remote Silurian regions of America, and it may be said that the Silurian deposits of Ireland are perhaps richer in American fossils than the English deposits. Supposing these relations true, many curious speculations might be founded upon them worthy of the attention of Mr. Austen. The next is the superposition of completely metamorphosed rocks over others in a comparatively slightly modified condition, passing as it were in a diminishing degree of metamorphism, from the supposed younger gneiss above, through micaceous flags, to the semicrystalline limestone with fossils. This seems to be a matter full of interest, and, assuming that the geological facts are correct, implies that we have yet much to learn respecting the true nature of metamorphism, at least as to the mode in which metamorphic action has been exercised; but I must still refrain from giving a decided opinion on a subject so replete with difficulties, in which two such able observers as Sir Roderick Murchison and Professor Nicol are still at issue.

The papers I have hitherto noticed have been prepared in conformity with the ordinary rules of the Society, and have more or less contributed to our knowledge in some one or other of the leading branches of geological science. The papers I am now about to refer to are, in some respects, less conformable to the rules of the Society, but are by no means devoid of interest and value, as they are intended to facilitate the appreciation of the labours of our Transatlantic brethren, by submitting them to us in a well-arranged and carefully considered form. You are all aware that Dr. Bigsby, the author of these papers, has never lost the enthusiasm which his travels, on a public and important duty, through the most remote and wild regions of North-west America, excited in his mind nearly forty years ago. I well remember him at that time, when his energies were at their maximum; and the bent of his mind was

even then well-marked, as he was the first to point out to me the remarkable veins of sulphate of strontian (Celestine) in the island of Lough Eric, now called "Strontian Island;" and I do not forget that he required me to forward to him a correct drawing of a trilobite from Lake Huron, then in my possession. He has lately been most industriously occupied in preparing a general Geological Map of North America, and (whilst engaged in that laborious task) having been doubtless led to observe and estimate the difficulty of wading through so many detached reports drawn up by independent United States geologists, has wished to spare others a similar necessity. His first paper treats of the mineralogical and fossil characters of the Palaeozoic strata of New York, and divides itself into the following heads:—"Mineral character," "Mode of transition," "Place," "Position or dip," "Thickness," "Fossils common and typical," "Fossils occurrent in Europe," "Fossils recurrent in New York."

As Dr. Bigsby's principal object is, to form a standard of comparison, by which the palaeozoic strata of New York may be brought into relation with those of other districts, he has drawn up tables, constructed from the writings of many preceding authors, both American and European; and, though he admits that some revision of the American fossils is still required, it cannot be doubted that his work will be a great aid to those who hereafter may undertake the systematic correlation of the palaeozoic formations of the whole earth. Admitting for the present the minute subdivisions of the palaeozoic formations by the American geologists to be correct, he proceeds to describe *seriatim* the seventeen subdivisions of the Silurian from the Potsdam Sandstone to the Upper Pentamerus Limestone, and the twelve subdivisions of the Devonian from the Oriskany Limestone to the Old Red Sandstone, under each of the distinctive heads I have enumerated. In this respect it is curious to observe the approximative horizontality even in the lower palaeozoic formations, though occasionally and very partially disturbed by local causes. The two terms, occurrent and recurrent fossils, represent, 1st, the correlation in fossils with European strata, and, 2nd, the repetition of the same fossils in successive American strata. In the Potsdam sandstone (the lowest member of the Silurian system), only one fossil is represented as *occurrent* in Europe and none as *recurrent* in America; but in ascending, the number both of occurrent and recurrent species increases; and the latter occasionally pass up to a much higher level. It cannot be doubted that all these considerations are of the highest interest; and when the fossils of America have been carefully compared with those of Europe, specimen with specimen, not figure with figure, so as to separate varieties from species and enable the geologist to avoid the introduction of old species into the catalogue as new, a correlation effected on the principles adopted by Dr. Bigsby will lead to a more correct knowledge of this great section of the palaeozoic formations. In his second paper he discusses the stratigraphy and classification of the whole series of the palaeozoic rocks, and agrees almost entirely with M. De Verneuil, the modifications proposed by himself being prin-

cipally characterized by the formation of natural groups in which are merged several of the sections adopted by the American geologists, and the establishment of a "Middle Silurian" stage, as also a similar Middle Devonian. This tripartite classification would of course assimilate these two great formations to the Permian and Triassic, and thus introduce a certain amount of harmony in the system of classification, even though it might not be an exactly true representation of nature. After a most careful lithological and palaeontological description of the strata, he deduces some interesting conclusions, as, for example, that all the strata from the Potsdam sandstone to the summit of the carboniferous were quietly deposited, being subjected only to occasional vertical oscillations and consequent superficial changes; and that the elevation, fracture, and metamorphism of the strata were subsequent to the deposition of the whole, in one prolonged operation, and in a N.E. and S.W. direction along the Appalachians, so well described by the Professors Rogers, whose views Dr. Bigsby fully states, though he does not entirely agree with them.

It is trusted that the preceding review of the works of the last session will prove that our members and contributors have exhibited zeal, energy, and ability in following up the study of every branch of our science; and that our foreign fellow-labourers have been equally zealous and successful: but, to the proof my previous citations have afforded, I may add a reference to the last publications of Von Hauer, Oppel, Jokely, Ludwig, Neumann, and many others, as being sufficient to show that in every quarter the materials are collecting which will hereafter enable the philosophic geologist to describe the history of the earth in all its physical and organic changes, though I cannot presume to trespass further on your attention by dwelling upon the works of these able authors; I must, however, notice very briefly some recent observations of M. Alph. Favre, Professor of Geology at the Academy of Geneva, on that portion of the stratification of Savoy which has so long been a puzzle to the geologist. M. Sismonda and M. Elie de Beaumont appear to have considered the several beds of coal as all belonging to one epoch; and the first of these eminent geologists having found in the bed of coal of Taninge the impressions of true coal-plants above, as he supposed, the jurassic strata, he adopted the bold assumption, that "in the Alps the coal-ferns continued to live on, whilst deposits were taking place in the sea, up to the nummulitic epoch," to which therefore he assigned the coal of Taninge; and M. Elie de Beaumont considered the coal of the Diablerets, Darbon, Taninge, &c. to be so far of the same age as to be all comprised within the nummulitic period. M. Favre, on the contrary, who is well known as one of the most active and successful explorers of Alpine geology, states that in the neighbourhood of Taninge, which he had often visited, he found at a high elevation a fine deposit of hypersthene and serpentine rocks not before noticed; that to the S.W. of Taninge, on the summit called La Vuarde, he collected very characteristic Liassic fossils; and that he traversed in every

direction the point of Taninge or the Dent de Marécly to the height of 7000 feet.

He then compared the coal of Matringe with the neighbouring bed of Taninge, and found the fossils of the lower Lias in the massive calcareous deposit *over* the Matringe deposit of coal, and determined that this mass is the same as that which *covers* the coal of Taninge. He therefore concludes that both these carbonaceous deposits are covered by deposits which from their fossils ought to be considered Liassic, and cannot therefore be considered in any respect as Nummulitic. M. de Heer has examined the specimens of fossil plants collected by M. Favre; and, though he differs in some respects from M. A. Brongniart and M. Schimper as to the species, he quite agrees with them in considering that they are truly Carboniferous; and, on his part, M. Favre maintains that the stratification is in accordance with that opinion. To the north of Taninge the nummulitic formation does not appear; but to the south it is found at between three and four miles from that town; and M. Favre imagines that its occurrence there has probably led M. Sismonda to class the coal with it, though in reality there is no connexion between the two formations. Without doubt, the obscurity of the stratification of the Alps must always render it very difficult to escape from error; M. Favre considers, however, that he has fully shown that, in the Alps, the more ancient jurassic strata are more highly developed than the nummulitic.

He then corrects the statement of M. Elie de Beaumont, by showing that the coal of Darbon, like that of the Cornettes de Bize, belongs to the upper jurassic, being distinguished from that of Taninge by its fossils; and the observations of M. Delaharpe and M. Studer are in conformity with his own. Again, the coal of the Commune d'Arraché, near the hamlet of Pernaut, described by MM. Sismonda and Elie de Beaumont, really belongs, as stated by those geologists, to the nummulitic formation; and it is therefore no matter of surprise not to find in it coal-ferns. The deposits of the Diablerets and Entrevernes are of the same age; and as M. Favre has noticed eight localities where this carbonaceous deposit is found, and has traced it from Savoy into the centre of Switzerland, it cannot, he observes, be considered a very local deposit. This determination of three distinct carbonaceous deposits in successive epochs is certainly more in harmony with nature than the supposition that the coal-plants had resisted all the physical changes which must have elapsed in so long an interval as that between the Carboniferous and Nummulitic epochs; and we may admit that M. Favre has not broken a lance, to use his own words, in favour of the value of fossil botany as an indication of the age of deposits, in vain.

I may mention, that Signor Cocchi has informed me that he is about to resume his researches on the geology of Tuscany, of which I took notice in my last address, and has promised another visit to England at no distant period to communicate the results of his inquiries into fossil fishes. But what I am particularly desirous to bring before you is the Report on the Geological Survey of Canada,

made by Sir W. Logan to the Governor of that colony, Sir Edmund Walker Head. The report embraces the labours of the years 1853, 1854, 1855, and 1856, and must, with its illustrative maps, be considered highly creditable, both to the observers themselves and to the press of Toronto, the former capital of Upper Canada, by which it has been published. In a comparatively new country, it is only natural that economic questions should be considered the primary objects of geological research; but it will doubtless surprise many, that Sir W. Logan should have been required by the Geological Survey Act to ascertain the longitudes and latitudes of important places, or, in fact, to fulfil one of the functions of the Topographical Survey; and for this purpose he has availed himself, wherever possible, of the electric telegraph in order to exchange and compare signals. The Laurentine rocks are described as gneiss interstratified with important masses of crystalline limestone, the gneiss frequently containing crystals of hornblende, and merging into a syenite which is traversed by dykes of a porphyry analogous to the melaphyr of the French; and it is worthy of notice, that the overlying fossiliferous rocks appear to have been sometimes deposited upon worn edges of the porphyry, which must therefore have been erupted before their deposition. Sir W. Logan considers four-fifths of Canada to stand upon the unfossiliferous rocks, and the other one-fifth to have become the seat of colonization from the superiority of the soil, produced by the decomposition of the fossiliferous rocks; he in like manner points out the natural direction given to settlement by a similar result produced by the decomposition of the crystalline limestone bands. Sir W. Logan remarks, indeed, that the lime produced from these bands is fully equal for economic purposes to that obtained from the more earthy limestones; for constructive purposes, I may say better fitted, as is certainly the case in Ireland, where the beds of limestone which alternate with the mica-slate of the north yield a lime much better suited for mortar than the rich (as it is technically called) lime of the chalk. ••

Sir W. Logan's first report is principally of a mineral or economical character, and he particularly notices the abundant occurrence of lime-felspar, or labradorite, which forms a component of mountain-masses. When it is remembered that this comparatively rare form of felspar was first noticed in the Island of St. Paul, on the coast of Labrador, and since by Dr. Bigsby in an island of Lake Huron, it may be fairly considered a mineral link by which the Laurentine and Huron groups of crystalline rocks may be connected together in one great system. The map, which illustrates this report shows that in the district, north of the Ottawa, the Laurentine group is immediately succeeded by the Potsdam sandstone. The inquiry to the westward was conducted by Mr. Alexander Murray, Assistant Provincial Geologist. In describing the district between the Ottawa and the eastern shore of Lake Huron, Mr. Murray points out many interesting physical facts in connexion with the numerous rivers and lakes of this remarkable country, in which the watershed-lines are singularly varied. The level of Lake Huron is quoted from

the reports of the Michigan Surveyors as 578 feet; and the bottom of that lake is doubtless, as I formerly observed, in many parts below the surface-level of the ocean, whilst other lakes occur at the level of 1400, 1300, 1200, and all the intervening levels, down to Round Lake, 521, or nearly 60 feet below Lake Huron, and Chats Lake, 233,—the country rising to the north, and falling eastwards to the Ottawa. The Laurentine series of gneiss and crystalline limestone occurs here fully developed, and is overlaid by patches of Lower Silurian shale; and Mr. Murray seems, from the fossils contained in some of the beds, to have recognized some portions of the series of four beds (Calcareous sandstone, Chazy limestone, Birdseye limestone, Trenton limestone) which follow the Potsdam sandstone. In further investigations, when he had the valuable assistance of Professor James Hall of New York, he carried the ancient rocks of Western Canada a little higher up, to the Trenton limestone and Utica slate, or nearly to the upper limit of the Lower Silurian.

Mr. James Richardson, another assistant-geologist, conducted the inquiries more to the east. Here, supposing that the Mingan Islands may be assumed to exhibit the lower or basic member (that is, the Laurentine system), Harbour Island the calciferous sandstone, Jauge Island the Chazy and part of the Birdseye formations, and the sea-interval to be occupied by a succession of strata about 1700 feet thick (assumed to be equivalent to the upper part of the Birdseye limestone, the Trenton formation, the Utica slates, and the lower portion of the Hudson-River group), the Anticosti rocks are formed into six divisions, of which the lower portion is considered by Mr. Billings to belong to the Hudson-River group, the middle as merging into the Clinton, and being more in conformity stratigraphically with the Oneida conglomerate and Medina sandstones, that is, distinctly transitional or Middle Silurian, Mr. Billings having adopted that term in anticipation of Dr. Bigsby. The upper section passes into the Upper Silurian; so that the whole series is here exhibited in a very moderate space. Mr. Billings has given lists of the fossils found in all these beds; and Dr. Bigsby's paper will be of great use in comparing them with the lists given by the United States geologists. The geological reports are concluded by a description of many new Canadian fossils by Mr. Billings, in which the great number of new species of Crinoids, of Cystidæ, and of Asteriadae is very remarkable. A new species is added to the genus *Bronteus* or *Brontes* of Goldfuss, as also one to the genus *Triarthrus* of Greene; and I may add, that here, as everywhere, the *Calymene Blumenbachii* appears to link together all the members of the Silurian, and, in my opinion, did it stand alone, would prove their identity as parts of one great natural-history system*. The final reports are chemical and mineralogical, by Mr. Hunt, the Chemist and Mineralogist of the Canadian Geological Survey.

In the United States there has been no cessation of that activity

* As yet no figures of these fossils have been published.

which for many years has distinguished the State and other geologists. The Geological Map of Pennsylvania has been finished in spite of many difficulties and the partial cessation of Government aid, by the two brothers Rogers, and was exhibited by Professor H. D. Rogers at the late Meeting of the British Association in Dublin. The rich fossiliferous deposits of Nebraska, which some years ago excited so much interest, from the numerous mammalian remains collected and afterwards described by Professor Leidy, have been again diligently investigated by Mr. F. B. Meek and Dr. F. V. Hayden. The attention of these able observers was first drawn to this region by Professor Hall, and they have been very successful in their researches. Their great object was to determine a parallelism of the Cretaceous formation of Nebraska with that of other portions of the United States' territory, and also to determine the true position of the Tertiary formations.

By the map which accompanies the account of their labours, it appears that on the S.E. corner of the Nebraska district Carboniferous rocks appear, that they are succeeded by the Cretaceous, and finally by the Tertiary deposits. Many new fossils are described, but as they are not figured, and are to appear in a report to be published by Dr. Warren, I shall merely state the general conclusions at which Dr. Hayden and Mr. Meek have arrived from the affirmative evidence of the fossils present, as well as the negative evidence of the fossils absent.

From the marked typical difference between the organic remains of the principal fossiliferous Cretaceous deposits of the south-west and those of the Upper Cretaceous beds of Nebraska, Alabama, and New Jersey, differences which cannot be wholly explained by local peculiarities, whether zoological or physical, the authors conclude that they belonged to different geological horizons, or, in other words, lived during different epochs.

The formations in New Jersey and Alabama are on a parallel with the *upper* and *lower* members of the Nebraska section, whilst those of Kansas, Arkansas, Texas, and New Mexico are on a parallel with the *middle* and *lower* portions. The Nebraska section, therefore, exhibits the fullest development of the Cretaceous formation in the United States.

In the Tertiary, Mr. Meek and Dr. Hayden come to the conclusion that the mammalian fossils formerly ascribed to the Eocene must be transferred to the Miocene; and there is no evidence of the existence of any Tertiary deposit in Nebraska older than that formation. I regret that I cannot devote more space to the works of these indefatigable observers, who have already made known to us the existence of a Permian deposit, in addition to the present and other works of geological interest.

Referring now to another region of the world, I may observe that I have heard from our fellow-member Mr. Oldham on his voyage back to India, and that he expresses himself with enthusiasm as to his hopes of future success, and his full confidence in the arrangements and the support of the East India Company. I have

been favoured by the Directors of that body with the perusal of many of the geological papers published under their auspices; and I can confidently state that a judicious selection from the work performed, which the recent institution of an establishment similar to our Museum of Practical Geology will hereafter secure, was alone wanting: and I cannot but therefore express a hope that, should the changes which are now the subject of public conversation and discussion be carried out, care may be taken that the interests of geological and other sciences will not be overlooked, but that the example of activity and judicious management which the Directors are now exhibiting in that direction may be followed by their successors*.

Many of the reciprocal connections of the several branches of the science are discussed in an able Report on the prize for physical sciences for 1856, by M. M. Elie de Beaumont, Fleurens, Is. Geoffrey Saint-Hilaire, Milne-Edwards, and Ad. Brongniart, in which the general views of palæontological science, as now generally entertained, are well explained, as well as the connexion which must exist between the organic and physical changes in order to produce one uniform and harmonious system. For example, "the study of mountainous countries has shown that the presence of fossil bodies on the most elevated points may be explained by the elevation of those mountains, in a more simple manner than by the depression of the waters of the sea; and hence has arisen the theory of the successive lifting up of mountains, which owes to M. Elie de Beaumont its principal development, but which, whilst it determines, with the contained fossils, the successive epochs of formation, does not explain the mode of creation, which still is, and probably must ever remain, a mystery. The treatise presented for the prize was one by the well-known Brönn, who, aided by his long experience, and taking advantage of the published labours of other eminent palæontologists, submitted classified lists of about 30,000 species of animal and vegetable fossils, distributed amongst 25 or 30 distinct epochs of creation. This expression naturally leads to the discussion of the theoretical views connected with it, or those views which are taken of the fact (which cannot be disputed), that at successive epochs lived distinct and successive forms of organized creatures. The mode, however, in which the changes of organic beings have been effected is a subject of fair speculation." Nor can any discussion do harm so long as disputants will remember that they are only dealing with a question of probability, not one of mathematical accuracy. Of the two great modes of accounting for the successive changes in the fauna of the world, advocated by those who maintain the invariability of species, the one advocated by Agassiz is, that all the organic bodies which existed on the earth at any one epoch were simultaneously destroyed, and replaced by a totally different group. The other, advocated by Brönn, is that only a part of the population of the earth, varying in

* These changes have been carried into effect; but geologists will feel at ease when they observe that Sir Proby Cautley has been appointed a member of the New Council of India.

magnitude at different times, was destroyed at any one epoch and replaced by a new group, whilst another portion continued to live on in combination with the newly-created forms. The French Academicians express themselves adherents of this view of the case, as well as of the further opinion, that the number of species destroyed always exceeds the number of those preserved. As a preliminary, the authors of the report reason against the theory of development, admitting, however, that they do not mean to oppose those variations in a species which might be fairly attributed to variations in the physical conditions (such even as man has effected on domestic animals), but those greater changes which were once supposed capable of producing, from one set of genera, others widely distinct in character and magnitude. But this reference to the opinions of Lamarck seems scarcely necessary at the present day, whilst it cannot be admitted by the philosopher, that there is any greater simplicity, as a mode of action, in destroying one set of organized beings and creating another in many respects closely allied to their predecessors, than in endowing all created organisms with a susceptibility of change under the varying influences of the several physical conditions to which they may be exposed. At any rate, let us not argue such a question by appealing to extravagant examples, but let us keep within the bounds of reasonable cause and effect—such, indeed, as our authors have admitted in respect to the variations of existing species. One great truth is admitted by the French academicians, namely, that the history of the ancient world is still incomplete; and well may this be asserted, when it is remembered that three-fourths of the surface of the globe are covered by water, and that, whilst large portions of the sea-bottom and of the marginal sea-zone of ancient epochs have been rendered manifest by fossil remains, the portions of dry land made known to us are comparatively small. Why, then, should we assume that every newly-discovered genus or species is a new creation, and not a colony (according to Barrande's view) from some other region, still submerged and therefore unknown to us? It is manifest that such a question cannot be answered until the whole field of ancient fossil history has been worked out. And, further, who can tell how creation was effected? but if by an act imposing laws upon matter, and calling into existence organisms subject to the controlling and modifying action of physical circumstances, why should not an alteration in these circumstances produce the same change in a created being, as they would work on the creations newly called into existence? Such a result would be more in harmony with the notion of creative intelligence, than that new species or new genera should be created by the same intelligence so nearly alike those destroyed as to require the utmost skill of the naturalist to distinguish one from the other. I cannot, at least, but think that we are very far still from the solution of the mysteries of creation, and that we are too prone to separate portions of the same true organic whole from each other, losing sight of the unity and harmony of creation whilst seeking to use the relics of past ages in geological classification.

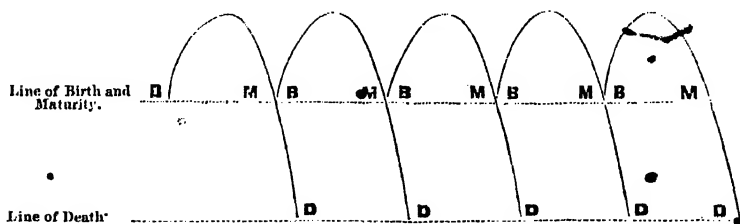
Having in my last address endeavoured to give a correct representation of the amount and success of the labours of the many eminent men engaged under Sir Roderick Murchison in the National Geological Survey of Great Britain and Ireland, I shall not now go over the same ground further than to state, that Mr. W. Baily has been attached to the Irish section of the work, and will, under the able superintendence of Mr. Jukes, be soon able to place the palæontology of Ireland on an equal footing with that of Great Britain: I trust he will be appointed palæontologist to Ireland, and have the means afforded him to emulate the bright example, and to secure the well-merited honours, of the English palæontologist, Mr. Salter.

Let me now close my address with a few general remarks, summing up, as it were, the views I have already expressed; maintaining as I do, that in all branches of geological inquiry there are still many important links of evidence deficient. At the same time let me add, that I consider we are on the right way now to get over all difficulties, provided we continue to adhere to the true principles of inductive science, and abandon the common custom of rushing wildly to conclusions upon the most vague and insufficient data. The Rev. Baden Powell says, in respect to the bearing of scientific progress on theological reasoning—"The unparalleled advances in physical science which characterize the present age alone suffice to stamp a totally different character on the spirit of all its deductions; and they now are, and will be to a far greater extent, influential on the tone of theology. It is now perceived by all inquiring minds, that the advance of true scientific principles, and the grand inductive conclusions of universal law and order, are at once the basis of all rational theology, and give the death-blow to superstition." And in like manner, that every true advance in science has a direct tendency to make men more scrupulous and careful in drawing deductions from facts observed.

The actual condition of the earth's crust; the order and manner in which the various changes from its primæval condition have been effected; the real nature of metamorphism, the means by which it has been effected, the original and the ultimate condition of the rocks acted upon; the nature of creation, the mode of progression and distribution of organic bodies,—are all subjects which men now think it necessary to examine patiently and systematically, neither jumping rashly at conclusions, nor flippantly sneering at those who see the same objects in a totally different light. We have every reason, indeed, to expect to obtain great results, because we are at last determined to follow after truth, whatever may be the path she takes, or the aspect she assumes.

It is this general recognition of the authority of truth which has enabled men of science to reason fearlessly on many subjects which were considered, not very many years since, proscribed from inquiry, and expected to be received and admitted without hesitation and without question: the mode of creation was one of these, as it was laid down as a rule that the Mosaic account was not only in *spirit* but in *letter* inspired, and that human discoveries were only illusions when

apparently in opposition to it. As ably pointed out by Professor Powell, the evil was only increased by those who endeavoured to escape from the difficulty by putting a constructive meaning upon the words, quite opposite to their literal sense, and then to adjust their theories to this new meaning. How different would have been the result, and how much bickering would have been avoided, had men attended only to the subject before them, and studied Geology for itself alone, and not as a supposed corroboration of statements, in what could never be considered a lesson in science! Well indeed may Mr. Powell maintain that proofs of inspiration ought only to be looked for in those manifestations of divine wisdom which are to be found in the precepts set forth for the moral government of men: to expect proofs of inspiration in other topics irrelevant to the main object of prophesying, would result only in fastening upon divine wisdom the ignorance and folly of erring man. I say this preparatory to making a few brief observations on the recent work of Mr. Gosse, entitled "Omphalos, or an attempt to untie the Geological Knot." Now, the geological knot appears to me to be the difficulty of explaining by what causes, and in what order, have been produced the various physical and organic phenomena observed in a study of the earth's crust, not in explaining the Mosaic account of Creation. Mr. Gosse thinks differently, and imagines that he has discovered a new law by which the observed facts of Geology can be put in harmony with the account of creation, or, in other words, that everything connected with the creation of organic life has been the work of the first six days. This is a bold assumption, and it must be admitted that Mr. Gosse has shown considerable ingenuity in the invention of very convenient terms, which serve instead of arguments; for to those who, adopting his theory, are not possessed of his ability, the words prochronism and prochronic must be of immeasurable advantage. But let us inquire into the nature of his argument. First, then, he represents the course of life as circular or cyclical; but, although such a course is real, in respect to many motions, such as that of the earth round the sun, the horse moving in a mill, and many others where the motion is necessarily, in accordance with the laws of motion, either in a circular or in some other re-entering curve (unless, indeed, we may suppose the comets sometimes to go beyond the limits of attraction, and be finally lost



in interminable space), in organic life it cannot be said that the true representation is a re-entering circular or other curve, as death

cannot be said to be the beginning of life. The true representation of life is rather a succession of open, or, as I may call them, eccentric cometary curves, one springing out of the other, as life begins, not where life ends, but *where it is in highest vigour*.

The plant and the animal, even, continue to live long after the new plant or the new animal has commenced its course of life. This, however, does not affect Mr. Gosse's argument, if we assume that the inquiry is limited to a part only of the curve extending from birth to maturity; for if creation were supposed to commence at old age, it would pass below the curve, and would then cease. The physiologist, then, having observed that there is a certain course of operations, of changes, of modifications, or of additions, called growth, in the passage from a seed to a tree, or from an ovum to a full-grown animal, most of which leave marks of their occurrence behind them,—is able to deduce, in the spirit of inductive reasoning, the age, or rather the epoch of existence from the visible marks of growth he finds upon the plant or animal; boldly therefore he says, This plant, or this animal, was 20 or 30 or more years old. But Mr. Gosse assumes that he has been deceived, because he knew not that this plant or animal had been created only that very morning, and was also ignorant of the great law of prochronic existence, which means (adopting some more tangible explanation than that of ideal existence) that, whilst the Creator was bringing into existence the plant or animal at any point of the supposed cyclical curve, the image of all the stages through which all future animals should pass flitted across His mind, and were incorporated in the new creation as a prophetic indication of what would take place hereafter. It is evident, however, that Mr. Gosse confounds two different things in this idea—namely, the laws which regulated creation, and the laws which regulated the progression and continuance of life. Plants and animals, for example, might have been created, as a statuary forms a statue, not to grow, but to continue permanently in one state of existence; but when the work of creation had ended, the laws of life were imposed; so that it is by no means necessary that the newly-created plant or animal should exhibit the workings of laws only required to bring up future organisms, by gradual steps, to the same condition which had been arrived at *instantaneously* by Divine will. Neither Mr. Gosse, nor any one else, has ever had a glimpse or a *revelation* of the *modus operandi* of creation, except in the one instance of the creation of Man, which affords no support to the prochronic theory, and cannot therefore be justified in assuming that it afforded an anticipation of what would be the product of growth. Indeed, it may be well to remind Mr. Gosse that, whilst he is apparently endeavouring to conform to the literal words of Scripture, he is seriously departing from the account there given of the first formation of man, which represents the created thing as without life, an inanimate thing, until the breath of life had been breathed into his nostrils; so that blood, and everything, whether fluid or solid, connected with organic life, were either created or adapted to the purposes of the new animal—not found existing, partly in perfect condition and partly

effects or experimental, as if it had previously existed, though that existence was ideal.

Admitting then the ingenuity of Mr. Gosse's reasoning so far as he restricts himself to animals or plants, the structure, functions, and growth of which are experimentally known, and even admitting that a work which accumulates so many interesting examples may have its value in exciting a taste for natural history, I regret that he should have thought it necessary to assist geologists over a difficulty which to them has no existence. For this purpose he hints (for he cannot affirm) that it is possible that the inorganic world may also be subjected to a cyclical course, and that the "prochronic" law may be recognized even in the earth's strata. The meaning of this must be, that what appears to the geologist, reasoning from the analogy of recent causes and effects, a series of successively deposited beds characterized by the relics of the organic life associated with each, was in fact a single creation, and that the several layers were so created rather than in one simple mass, in order to typify the future formation, by the ordinary processes of nature, of other masses—masses which may therefore be studied hereafter by the relics of other generations of organic beings with accuracy and reason, although all our present studies are mere delusions. The extension of the same reasoning to the fossils, and the supposition that they may typify some future state into which existing animals may be intended to pass as the cycle proceeds, is manifestly in opposition to the very explanation suggested rather than given of Prochronism: for assuredly fossil bones and fossil teeth, or fossil plants, cannot be considered ideal; and although the author repudiates the old notion of *lusus Naturee*, it is difficult to conceive what better notion could be formed of the numerous organic relics which are every day being discovered, if they are not admitted to have been once living organisms rather than mere idealities. I do not dwell on Mr. Gosse's effort to explain away the astronomical fact of the vast space of time which must have elapsed before the Mosiac record of the creation of man as proved by the long period required for the passage of light, before some of the fixed stars could have become visible to man, namely, that the undulation might have commenced at the eye, and proceeded to the star, rather than at the star, and proceeded to the eye; leaving it to astronomers to notice, should they think it deserving of their attention. I should not have dwelt so long on this work, had I not heard an able geologist and scientific man declare that he thought the argument indisputable; and therefore I presume that he considered the opinions of all living geologists fallacious, founded on their mistaking ideal creations, both organic and inorganic, for real *bona fide* plants, animals, vestiges of marine, lacustrine, and fluviatile organisms, deposits of deep seas, volcanic ashes and lavas of all ages. Let us hope at least that no one will again endeavour to solve the supposed geological knot, but allow geologists to study and understand nature as they find her.

Another matter which has much engaged attention lately, is the degree of antiquity of man, as also the question whether man was

created unlike other animals, as one species only, or was created in numerous species adapted to the physical conditions of various localities, such as we now find them. The latter question is intimately connected with the first; for if we once satisfy ourselves that the races of men found in portions of the earth, which during the historic period could have had no possible connexion with the seat of the leading race of men, must have been independent creations, there is no absurdity in considering that they are remains of the organic human inhabitants of some earlier stage in the earth's progressive change. However, independent of any such speculation, M. Agassiz has adduced strong reasons for admitting an original plurality of human species, in his contribution to the work of Nott and Gliddon on "the indigenous races of the earth;" and after advocating the judicious principle, "that in the study of the races of man much light might be derived from a careful comparison of their peculiar characteristics with those of [the lower] animals," he selects the monkeys as being most nearly allied to man, and points out the differences of opinion which have existed amongst the most able naturalists as to the unity or diversity of species in some of the tribe—as, for example, in the orang-outans, those of Borneo, Java, and Sumatra being considered by some eminent naturalists such as Wagner as constituting only one species, whereas others, as Professor Owen and the American naturalist Jeffreys Wyman, consider them as constituting three distinct species.

The singular manner in which particular races are localized within narrow limits, as if specially adapted to them, is compared with the similar adaptation of the races of men to special localities; and it is urged that there is equal reason to consider that man has, like the monkey tribe, been originally created in varieties or in species, fitted for the regions to which they were to be attached. The philological argument for the unity of man is also discussed on the same principle of comparison with animals, in which a similarity of language, as it may be called, may be traced over the whole world amongst animals or birds of the same families.

These are not flattering, but they are philosophical views of the subject; and I dwell upon them, not with the desire of enforcing any opinion against the conviction of conscientious men of any creed or doctrine, but simply for the purpose of claiming for geologists the right of studying the works of nature on scientific principles alone. Even then we must be often obliged to modify our opinions, and to give up our most cherished theories; for it must be recollected that our science is even yet in a course of growth, and that the light of each new day may enable us to discover new facts and to correct old errors, just as the increasing power of the telescope enables the astronomer to penetrate into stellar spaces before veiled from his vision. In truth, the age of blind belief has passed from geology, and everything is now brought to the test of rigid examination: for example, how long have we now admitted as a demonstrated truth, though at first not an undisputed one, that the heat of springs, &c., was due to the communication to them of internal heat, proceeding from the still

heated nucleus of the earth ! and yet, as I have before stated, our able member and former President, Mr. Hopkins, has, from a comparison of the conductivity for heat of various mineral substances, shown that the heat observed does not vary in proportion to these conductibilities, and hence that we may perhaps have to abandon this favourite theory, and seek for some other explanation of a positive and well-known fact.

Such advances in knowledge ought not, however, to distress us ; but on the contrary we ought to feel that, however charming any cherished fancy may be, the discovery of truth is to a rational being far more so. A fairy tale may gratify and amuse the child ; but the man can only find instruction and enjoyment in the pages of true history.

Having now completed my allotted duties as your President, I relinquish your chair with a full confidence that you have elected as my successor the very best person who could have been found in any country for filling such an office. I have indeed pointed out how wide the range of geological science has now become ; and I know that in Professor Phillips you have obtained a President fully able to master the subject, however extensive and however difficult. I undertook the task myself with doubt and hesitation ; but such has been the kindness and support I have experienced from all the members, and from none more than our most able Assistant-Secretary, Mr. Jones, that the office I undertook almost with alarm has been to me a source of unalloyed pleasure, and will be ever remembered with gratification and with pride.

